CALIFORNIA FISH AND GAME

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VOLUME 42 JULY, 1956 NUMBER 3

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REPORT ON THE DISTRIBUTION AND ABUNDANCE OF PACIFIC HERRING (*CLUPEA PALLASI*) ALONG THE COAST OF CENTRAL AND SOUTHERN CALIFORNIA[1]

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INTRODUCTION

With the continuing search by the fishing industry for marketable products with which to fill the economic gap caused by the lack of sardines, interest in the utilization of Pacific herring (*Clupea pallasi*) along the coast of California has increased. During World War I there was some reduction of herring into fish meal, but a law prohibiting the reduction of whole fish of any species except by special permit was enacted in 1921. During the period 1920-1946 a steady but limited fishery continued (Figure 1) and since 1947 increased catches have

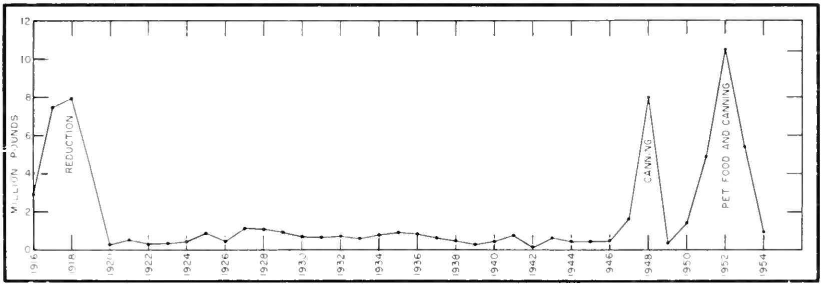

FIGURE 1. Herring catch in California, 1916-1954.

resulted from repeated attempts to can herring for human consumption and for pet foods.

In 1954 and 1955 several requests for permits to reduce herring to fish meal were denied by the California Fish and Game Commission on the grounds that the herring population in California was relatively small and that reduction of whole spawning fish would not constitute efficient economic utilization of the fish. This reduction of whole fish is the only phase of the herring fishery subject to regulation by the Fish and Game Commission. The catch for bait and commercial processing for pet and human consumption is unrestricted.

Because of the increasing number of requests for reduction and because of the future probable increased use of herring for food and bait, a summary of existing knowledge of the biology of the Pacific

[1] Submitted for publication February, 1956.

herring was undertaken, and, in 1955, an intensive survey was made of the central California spawning grounds to estimate the abundance of herring in California.

This paper presents the results of the sampling of the commercial catch conducted from 1947 through 1952 by J. B. Phillips of the Marine Fisheries Branch and the results of the spawning population survey conducted from December, 1954, through March, 1955. Many members of the staff of the Marine Fisheries Branch participated in the field work and their contributions are greatly appreciated.

THE FISHERY

The Tomales Bay and San Francisco Bay herring fisheries, described by Scofield (1952), occur during the winter (December to March) and depend upon spawning fish coming into the protected areas of the bays.

For many years there has been a steady but limited summer fishery in Monterey Bay, where herring are taken for bait with gill and lampara nets. Here most of the catch is made in the summer months and includes immature, one- and two-year-old fish, along with the mature adults. In 1948, and in 1951, 1952, and 1953, herring were processed experimentally for human consumption by plants in Monterey and San Francisco. Also in these years, a considerable amount of the catch was trucked to southern California for use in pet foods (Figures 1 and 2). This brought a marked increase in the summer catch.

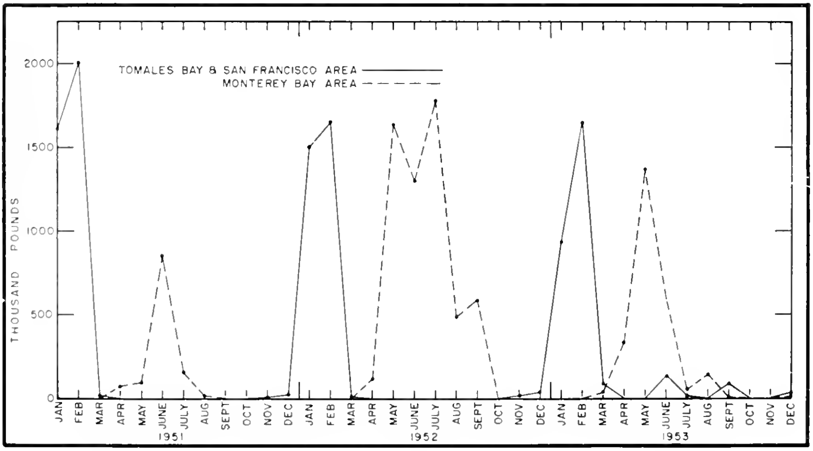

FIGURE 2. Herring catch by months in the central California area, 1951-1953.

Sale of canned herring for human consumption did not meet with success and herring are no longer desired by most processors for this purpose. The fish tended to break up in the can and the taste was not attractive to most persons. Adult herring were packed experimentally in southern California in such a manner as to render the pack appealing to both taste and eye, but the cost of producing this style of pack was prohibitive. Only small amounts of herring are now being taken

for use in pet foods, since cheaper and better quality fish are readily available to the southern California plants.

There is a newly developed minor herring fishery for dead and live bait in the Avila-Morro Bay region of central California. This fishery, conducted with lampara and small bait nets, is primarily a summer fishery. Salmon (*Oncorhynchus*) and lingcod (*Ophiodon elongatus*) are reported as greatly attracted to the hook when herring are used as live bait.

The San Diego fishery relies on gill nets, with most of the catches made from December to February. Only one or two fishermen have engaged in this small fishery. The herring is used chiefly as dead bait.

BIOLOGY

Atlantic or European and Pacific Herring

The two most commercially important species of herring in the world are very similar in appearance. The Atlantic or European herring (*Clupea harengus*) is distributed along the northeast coast of North America, off Iceland, the Faroes, and the British Isles and along the northern shores of the European mainland. It is the young of the Atlantic herring that is used in the Maine "sardine" packs. The Pacific herring (*Clupea pallasi*) ranges from central Japan northward along the Pacific coasts of Siberia and Alaska and south along the Canadian and American Pacific coastline to San Diego, California.

In behavior, the Atlantic herring differs from the Pacific species principally in that the former spawns in deeper waters farther from the shore than does the Pacific herring. The Pacific herring is known to spawn primarily in the intertidal zone, with an occasional spawning extending down through the intertidal zone to a depth of at least 6 fathoms below mid-tide level.

On the coast of North America the Atlantic herring spawns in depths of from 2 to 30 fathoms and offshore as far as 25 miles (Carson, 1943), and in Europe the Atlantic herring spawns well offshore, where the adhesive eggs become attached to gravel and shell fragments on the outer banks.

Of the periods of spawning of the two species Rounsefell (1930) writes: "In the Atlantic there are in many regions two groups or populations of herring known as spring spawners and autumn spawners, according to the season of the year at which they spawn, but in the Pacific, although the time of spawning may vary from December until June according to the locality, there is but one spawning season in each area."

In California, as in Canada and Alaska, there is but one period of spawning, extending from December through March, and as many as five or six spawnings may occur in each locality during this four-month period.

Length and Growth

The largest Pacific herring recorded (Rounsefell, 1930) was taken in 1928 in Unalaska and was 15 inches in total length, although herring as long as 16 inches in total length were unofficially reported from the central Alaskan area during this same period.

Herring in Californian waters do not attain as great a size nor do they live as long as the herring farther to the north. The largest recorded herring from California was a female 224 mm. in standard length (approximately 10½ inches total length) but larger herring, up to 11½ inches total length, have been reported by fishermen.

Herring in Alaska have been known to live 19 years, but the oldest herring taken in California (San Francisco Bay) was only nine years old. The growth rates of Tomales Bay herring, caught in 1955 (as computed from calculated lengths by use of age rings on scales) differ from Alaskan herring (Rounsefell, 1930). Herring in Canada and Alaska are spawned later and in colder water, resulting in a shorter and slower growing period for the first year. Not until after the second year's growth do herring to the north attain a size comparable to Californian herring of the same age. After the second year Canadian and Alaskan herring grow faster, reach a much greater size, and live longer than do herring in California.

Age Composition

The progression of modes of Monterey Bay yearling (1947 year class) herring from December, 1947, through August, 1948, and again for the 1951 year class from April, 1952, through September, 1952 (Figure 3), substantiated the age readings interpreted from the scales. The December, 1947 fish, ranging from 110 to 150 mm., had no rings on the scales and were approximately one year old, having been spawned in the January-March period of 1947. By June, 1948, these fish, then averaging about 145 mm., had one ring situated near the outer edge of the scale. For these June fish, calculations based on scale readings were made of their size at the time of formation of the first ring. These indicated a size comparable to that of the fish taken in December, 1947, thus suggesting that the same group of fish had remained in Monterey Bay and had grown approximately 15 mm.

The selective gill net (1¾ inch stretched mesh) fishery of San Francisco Bay takes only the largest of the herring in the population and these fish are not representative of the true age composition of the spawning population (Figure 4). The samples of lampara, purse seine, and beach seine catches made in Tomales and Monterey bays represent the adult fish present at the time of collection, but to sample adequately the entire spawning population a complete series of samples should be taken over the extent of the spawning period. According to Tester and Stevenson (1947), working in Canada, and observations of fishermen at Tomales Bay, the largest of the adult mature fish often enter the bays during the first of the spawning period, and are followed by smaller fish that apparently mature later in the season.

Age determinations of the 1955 commercial catch (Figure 5) indicate that approximately 22 percent of the catch of Tomales Bay herring was composed of fish two years of age and that no yearling herring were taken. Two- and three-year-old fish (1953 and 1952 year classes) dominated the Tomales Bay commercial catch in 1955, making up 84 percent of the total. The two- and three-year-olds also predominated in the 1952, 1953, and 1954 Tomales Bay catch. Stevenson et al. (1951) reported only a trace of one-year-old and only 2.5 to 9.8 percent of

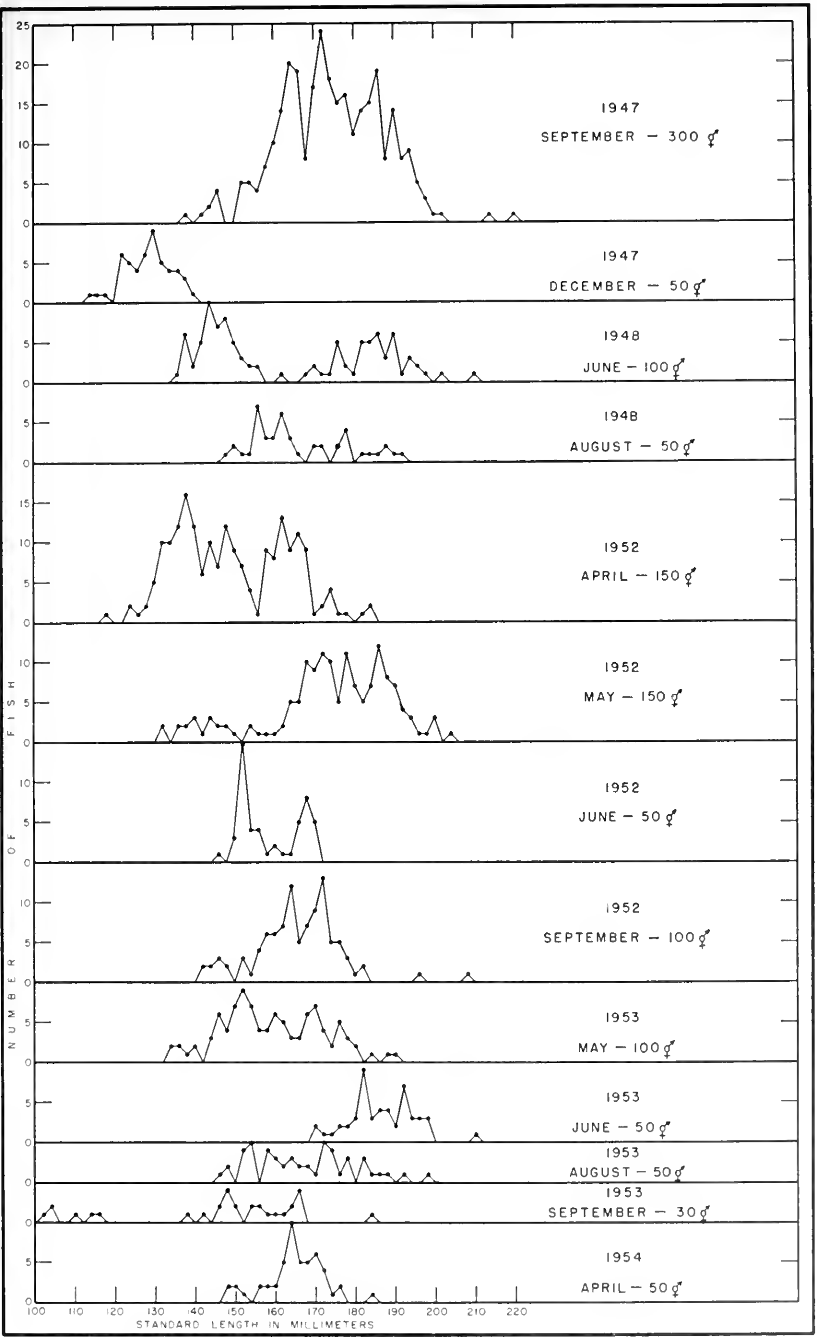

FIGURE 3. Length-frequency polygons of the Monterey Bay commercial herring catch, 1947-1954.

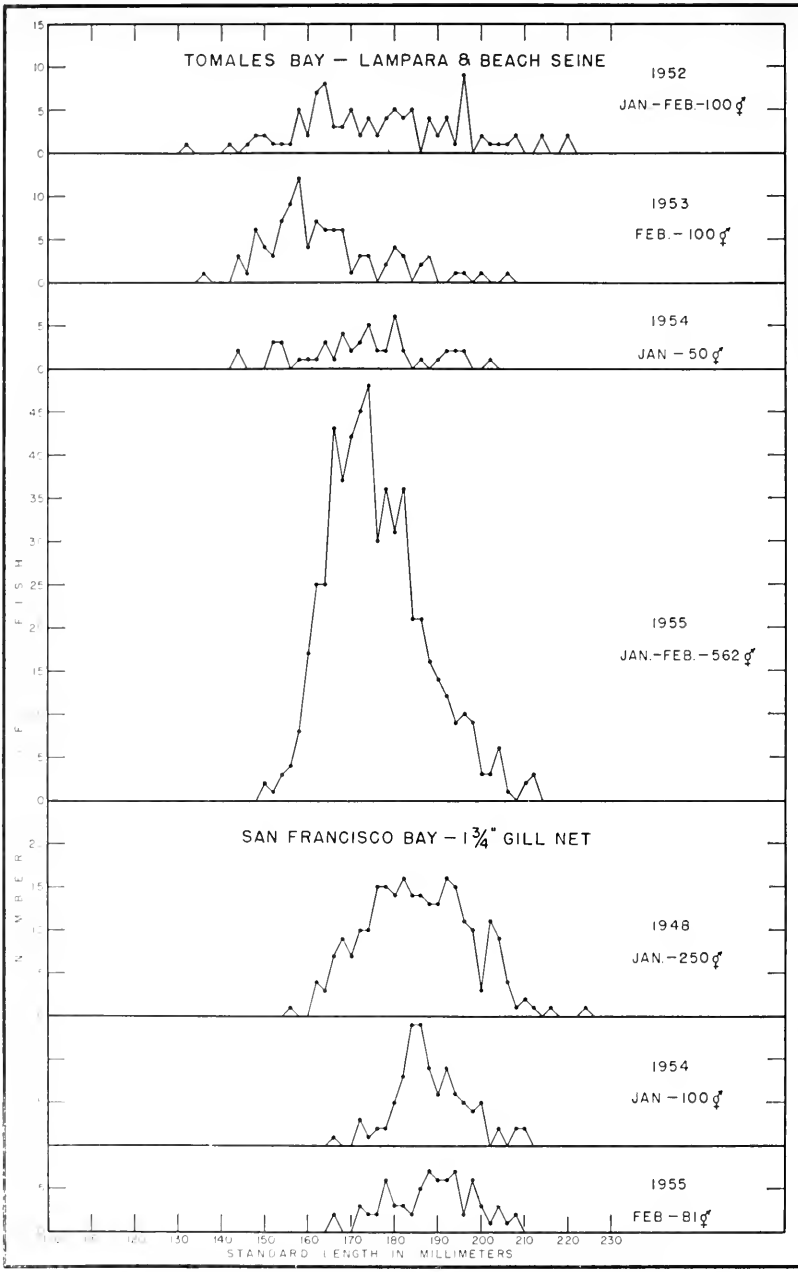

FIGURE 4. Length-frequency polygons of the Tomales Bay and San Francisco Bay commercial herring catch, 1948-1955.

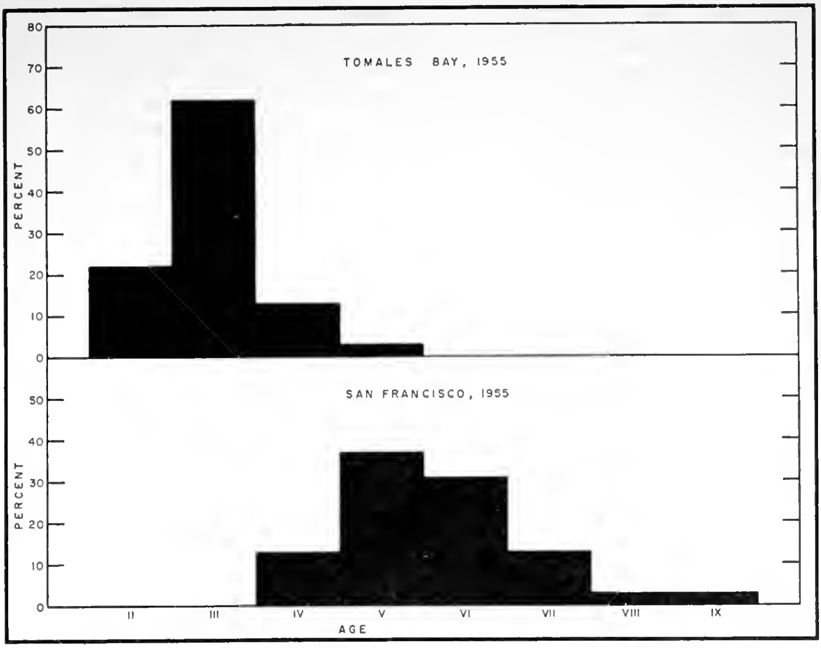

FIGURE 5. Age composition of the Tomales Bay and San Francisco Bay commercial herring catch in 1955.

two-year-old fish in the commercial catch off Vancouver Island in 1946-1951, with the three- and four-year-olds most abundant. (The fishery off Vancouver is conducted in the months immediately preceding the spawning season.) The data from California suggest that herring in California mature at an earlier age, with a greater percentage of two-year-old fish on the spawning grounds.

The composition of the San Francisco gill net catch consisted mostly of older fish, ranging from four to nine years of age, with the five- and six-year old fish (1950 and 1949 year classes) dominating the catch. Herring less than 160 mm. in standard length are seldom gilled in the nets used by San Francisco fishermen and a disproportionate number of large fish are caught out of the total spawning population.

Behavior

Spawning

In California, insofar as known, the Pacific herring spawns only in estuarian and bay regions. No herring spawn has been found on the open coast exposed to continual wave action. For many years crab fishermen working out of San Francisco, Point Reyes, and Bodega Bay have reported clusters of what they thought were herring eggs adhering to the wire mesh of the crab traps and to the lines attached thereto. These eggs were found from San Francisco north to the mouth of the Russian River in depths as great as 30 fathoms. Examination of several samples showed that they were not herring eggs and were probably eggs

of a blenny-like fish. They are smaller than herring eggs, ranging in size from 0.99 mm. to 1.18 mm. in diameter, whereas herring eggs range from 1.32 mm. to 1.75 mm. in diameter. An attempt to hatch clusters of these eggs for use in specific identification was unsuccessful.

Hart and Tester (1934) found that approximately 18,600 eggs were deposited by female herring averaging 192.5 mm. in standard length and that 29,500 eggs were deposited by a female 223 mm. in standard length. The adhesive (but not sticky-to-the-touch) eggs are deposited by the female on practically any clean substrate within the area where spawning takes place. The principal substrate used in Tomales Bay is eel grass (*Zostera marina*), whereas the principal substrate in San Francisco Bay, where eel grass is not abundant, is bare rocks or the many species of shallow-water algae growing on the rocks in the intertidal zone.

It is not entirely clear just why herring spawn where they do, although in California at least quietness of the water is apparently of considerable importance. In Canada no clear-cut association of spawning with salinity (influence of fresh water in this case) has been discovered. In Tomales Bay in 1955 the most lush beds of eel grass were not utilized for spawning, whereas beds of poorer quality and much less abundance were used consistently throughout the spawning season. These observations indicate that calm water and presence of the proper substrate are not the only factors essential for the location of a desirable spawning area.

Mass spawnings in San Francisco and Tomales bays may take place in a few hours of one night or may extend over a period up to five days or a week. After the fish spawn they return immediately to sea; later other schools of pre-spawning herring enter these bays and build up into very large schools. In 1955, the spawning periods occurred roughly at two- or three-week intervals.

Spawn Deposition and Incubation

During the heaviest spawning in San Francisco Bay in 1955, layers of eggs as deep as one and one-fourth inches were deposited on the rocks near Tiburon. Spawn deposition up to two inches thick has been reported (Croker, 1930), but generally, at least in California, spawn is no deeper than one or two layers of eggs. An index devised by Hourston (1953) to measure the intensity of spawning in an area is given in Table 1. Based on this scale, no very heavy spawnings have been observed

TABLE 1

Herring Spawn Intensity Scale (From Hourston, 1953)

Intensity	Number of eggs per square inch of *Fucus* or per linear inch of other types of vegetation
Very light	1– 50
Light	50– 200
Medium	200– 500
Heavy	500–1,000
Very heavy	over 1,000

on California grounds, and usually they have been only of very light and light intensity.

The eggs are deposited at various levels of the intertidal zone, and also below this zone, where they are never exposed to air. In situations such as these many fluctuations in temperature, salinity, etc., occur and the hatching time may extend well over a week because of differential development of the eggs. In California in 1955, eggs hatched from 6 to 11 days after spawning, with the water temperatures ranging between 8 and 10 degrees C. (46.4 and 50.0 degrees F.). Stevenson (1950) found in Canada that eggs deposited on March 15 reached a peak of hatching in 11 to 13 days, whereas eggs deposited in the same area on March 25 reached a peak of hatching in 8 to 9 days after spawning.

Pre-spawning Behavior

Prior to spawning, fish in Tomales Bay remain near the center of the bay, often schooling well below the surface in the deepest areas. Not until one or two days before and during actual spawning can the beach seine fishermen catch fish along the shore line. During 1952, lampara fishermen in Tomales Bay were able to catch schools of pre-spawning adults in the deeper holes before spawning took place.

In San Francisco Bay, herring concentrate in large pre-spawning schools in the Raccoon Strait area and in the area between Sausalito, Angel Island, and Alcatraz Island. The daily tidal fluctuation is greater in San Francisco Bay than in Tomales Bay and, during periods when the tide is running strong, the herring remain well below the surface in deep areas and behind submerged reefs and banks. Echo-sounding tracings (Figure 6) demonstrate this behavior.

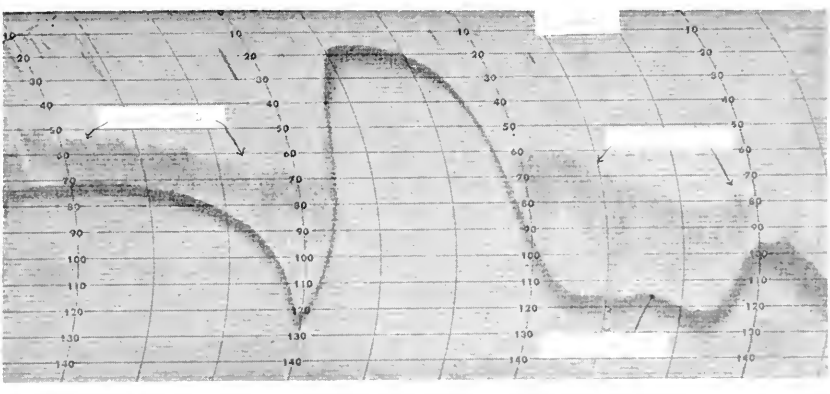

FIGURE. 6. Echo-sounding tracing of a Pacific herring school in the Raccoon Straits area of San Francisco Bay in February, 1955. Depths are in feet.

During periods of slack tide these same herring often school near the surface and swim rapidly about in the immediate area. A series of echo-sounding tracings made in San Francisco Bay also revealed that there was no measurable difference in depth of schooling between night and day during comparable stages of tide and water flow.

Sardines, mackerel, anchovies, and juvenile herring have been attracted by a light suspended over the side of a boat, but all attempts

to attract pre-spawning herring to a light have failed. On one occasion aboard the M. V. NAUTILUS a photobeam light was suspended over a school of herring that was stratified between 20 and 40 feet below the surface. The only reaction, indicated by echo-sounding tracings, was that the fish dropped slightly deeper so long as the light was on.

Post-spawning Behavior

Herring spawning in Tomales and San Francisco bays apparently return immediately to sea after spawning. No spent adult herring has ever been sampled in California on the winter spawning grounds where the fishery is conducted. In Canada, however, Stevenson et al. (1951) found that about 25 percent of the herring sampled in the spawning runs along the Vancouver coast were spent fish, indicating that the complete movement of spent fish from the vicinity of the spawning grounds may not be a common behavior in other Pacific herring subpopulations.

During the summer resting period, adult herring have been found only in the Monterey Bay and Estero Bay areas. In the summer months fishermen also report fairly large schools of herring offshore from the Farallon Islands, but no samples of these fish have been obtained. During the periods immediately before and after spawning, no adult herring have been found in any quantity anywhere in Californian waters. Apparently, there is a period of a month or two months before and after spawning during which herring are moving to and from the summer resting areas and cannot be located (Figure 2).

Subpopulations

Extensive tagging with internal metal tags, by Canadian biologists, has demonstrated the presence of several subpopulations of herring along the Canadian and Alaskan coastlines. Pacific herring have a "homing" instinct which brings them back to a certain area of the coast to spawn each year, although there is some intermingling of adult herring between adjacent areas. No tagging has been conducted in California, but based on the Canadian evidence there may be four to eight or more subpopulations of herring along the coast of California. The known spawning areas are: San Diego Bay, San Luis River, Morro Bay, Elkhorn Slough, San Francisco and San Pablo bays, Tomales Bay, Bodega Bay, Russian River, Shelter Cove, and Humboldt Bay. Herring are also believed to spawn in Los Angeles Harbor, Santa Ynez Lagoon, Salinas River, Drakes Bay, and at Ft. Bragg, but as yet the spawning grounds in these areas have not been found (Figure 7).

THE 1955 SPAWNING POPULATION SURVEY

Purpose

In comparison with the large populations of Pacific herring in Canada and Alaska, the population of herring in Californian waters is small, but we need to know just *how* small. With a potentially large take for pet food, bait, and canning ever present, special reduction permits cannot be granted without a knowledge of the total size of the stock. This study was undertaken to estimate population size by a survey of the areas of spawning, the number of spawnings per season in each area,

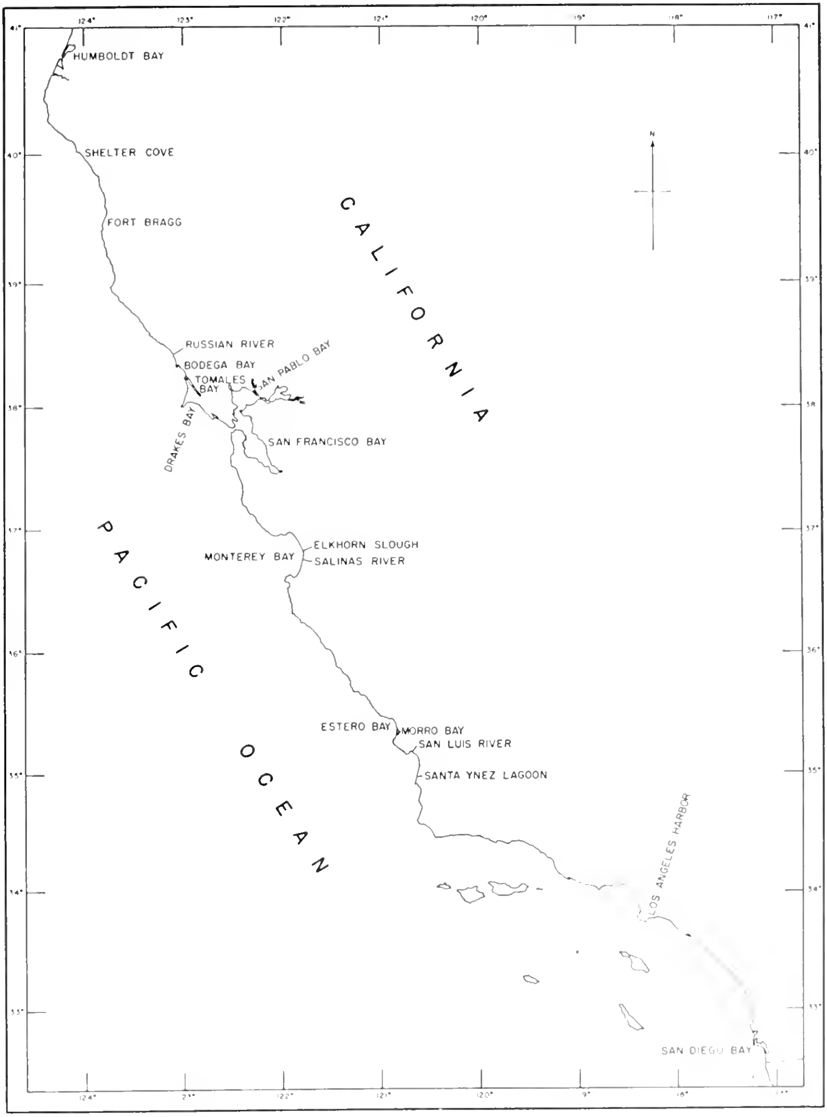

FIGURE 7. Spawning areas of the Pacific herring along the coast of California.

and the amount of egg deposition at each spawning. Echo-sounding tracings of pre-spawning schools were also used.

Methods

The above methods of population estimates have been employed by Canadian researchers with considerable success. Tester and Stevenson (1947) found that the amount of spawning was roughly proportional to the catches in the various areas along the west coast of Vancouver

Island and Hourston (1953) found a close correlation between spawning population estimates derived from spawn surveys and estimates of tonnage present in the same area as determined by echo-sounding.

In 1954, several field trips were made, covering most of the known spawning areas. Only in San Francisco and Tomales bays were large enough concentrations of spawning found to warrant an intensive survey. The San Francisco Bay area proved to have many complex topographical and tidal characteristics, and difficulties were encountered in the collection of adult samples and in the survey of spawning grounds.

San Francisco Bay

Echo-soundings of fish schools in San Francisco and San Pablo bays were conducted on the M. V. NAUTILUS, using a *Bendix* model DR 1 recording echo-sounder. A routine cruising pattern was set up to cover the navigable areas of the bays at least once and often twice weekly throughout the spawning period.

The echo-soundings proved to be of limited value in the rapidly flowing tidal waters of San Francisco Bay. Herring schools rarely remained in an area long enough to permit measurement of all the necessary dimensions of the school. The following method was used on the M. V. NAUTILUS in tracing schools: a school of fish would be located ahead or to the side of the vessel by means of a *Sea Scanar* (Minneapolis-Honeywell) and the course of the vessel would be altered, if necessary, to run through or over the center area of the school, so that the "length" and the depth of the school could be measured on the recording echo-sounder. To obtain a "width" measurement the vessel would be turned about, after having passed over the school, and the course directed to return at right angles over the area where the school had been located previously. Theoretically, these measurements would give a three-dimensional picture of the school, but in almost every case the school could not be located on the return trip, or if it were located, only a small edge would be found as the school was maneuvering about in the fast moving waters.

Another difficulty was identification of the school to species. This is of particular importance in San Francisco Bay, which is inhabited by many species of schooling fish. Experimental tows were made with a three-foot diameter hoop, upon which webbing was fastened to form a funnel-shaped trawl net. A depressor bar was attached to the hoop to force it, in an upright position, downward into the school of fish. This high-speed net (donated by the U. S. Fish and Wildlife Service) met with little success, although on each drag, made at various speeds and depths, one or two fish were taken. These consisted of herring or some of the other pelagic fishes present in the area, including the eulachon (*Thaleichthys pacificus*), northern anchovy (*Engraulis mordax*), and jack smelt (*Atherinopsis californiensis*).

Since the three-foot hoop net caught a few fish, a six-foot diameter hoop net was tried in the hope that it would take an adequate sample. The results were comparable, however, to those of the smaller net and this procedure was abandoned.

Emphasis was then placed on the blanket net sampling method (Radovich and Gibbs, 1954). Since adult herring had been taken under a light by the M. V. YELLOWFIN in Monterey Bay in November, 1954, a blanket net similar in structure to the one used on the M. V. YELLOWFIN was

constructed. This net was so arranged that it would drop into the water from the outer tips of the poles and could then be drawn beneath the fish by pulling the leading edge of the net toward the ship. This adaptation of the blanket net was not successful because: (1) the webbing was carried about and twisted by the moving waters, thus decreasing considerably the efficiency of the net and (2) herring were found to have no positive reaction to the light in San Francisco Bay. Presumably, herring taken under the light in Monterey Bay in 1954 were attracted not by the light but perhaps by the food organisms concentrated in the light zone. The failure of the blanket net necessitated the abandonment of this sampling technique.

Gill netting, although a successful method for herring capture, is time consuming, and all schools can not be sampled, especially in areas where gill netting is impractical. To obtain samples of the schools for biological studies, however, several 1¾-inch stretched mesh gill nets were set in areas where echo-sounder tracings indicated the presence of a school of fish. Most of the schools encountered remained deep (below 30 feet), so the gill nets were weighted and lowered into the depth where the fish were. One end of the net was secured to a float or small skiff and in all cases in which herring were caught they were entangled in the meshes near the bottom of the net. Several samples of jack smelt were also collected in the gill nets, but in all cases these fish were caught in the meshes that were near the surface of the water.

The spawn deposition survey met with more success in San Francisco Bay than did echo-sounding. Periodic examinations conducted at least twice a week throughout the spawning season were made along the shore lines of San Francisco Bay and the islands in the Bay. Evidence of spawning was easily determined by actions of birds and by visual observations of the spawn during low tide intervals. Aerial flights were made over the entire central California area between Monterey and Bodega Bay. These flights were made in a Model 180 *Cessna* and were conducted at intervals of a week, or at the longest, two weeks. In this way, outlying areas such as Drakes and Bodega bays were checked easily. There was a definite correlation between the presence of herring schools and deposited spawn and the activity of several species of gulls, cormorants, grebes, and pelicans. The birds were either feeding or diving upon the spawning fish or, in the case of gulls, eating the eggs during a low tide period. In every case that the aerial observer located an active group of gulls along the shore line, a check by an observer on the ground revealed the presence of herring eggs.

Tomales Bay

The physical topography of Tomales Bay, consisting mostly of mudflats spotted with eel grass beds, contrasts sharply with the rock-lined shores of San Francisco Bay. In Tomales Bay, spawning is confined primarily to the eel grass beds, most of which are below the low tide level. These beds were easily located by means of aerial photographs made during a low tide period. A flat-bottomed, motor driven barge was chartered once a week to check and sample the entire shore line, as well as the eel grass beds. A station plan was drawn up and on each trip the same areas were sampled by means of an eel grass sampler, consisting of two garden rakes welded back to back and fastened to a line. Samples of

eel grass, as well as of kelp and various other species of "rock weeds", were obtained quickly by moving the barge over the chosen spot, dropping the rake to the bottom, and retrieving it. Careful search was made of each haul and if herring eggs were present a random sample of the eel grass and eggs was preserved. A few shore trips by automobile were tried but because of the mudflat areas between the shore and the eel grass this method was abandoned and greater emphasis placed on working with the barge.

Spawning Areas in California

The following is a general description of the known areas utilized by spawning herring, with all the data collected to date concerning these areas summarized in brief form.

San Diego Area

Spawning starts in the south bay region (Harry Godsil, personal communication) of San Diego harbor in mid-or late December, which is about a month earlier on the average than along the coast farther to the north. The population spawning in San Diego harbor is not likely to be of much magnitude because of the limited spawning area and in view of the fact that only small numbers of herring have been observed throughout the many years of fishing activity in this area. The fish caught are used for dead bait. This fishery has been conducted by only one or two fishermen using gill nets.

A few juvenile herring were caught in the north bay in a seine haul (April 1948, Dr. Carl L. Hubbs, field notes) and the largest herring on record from that area was a 212 mm. (standard length) fish taken in a gill net off La Jolla in 1952. It is not known where the herring in this region spend the off-spawning season. Several scattered individual samples have been collected at La Jolla, Santa Catalina Island, and San Pedro Breakwater, but in the summer months no concentration of herring has been found in the area south of Point Conception.

Avila-Morro Bay Area

Little is known of the dates and intensity of spawning in this area, but all observations indicate that more herring are present than was previously supposed. The San Luis River estuary at Avila is a known location of one or possibly two very small and light spawnings each year. The total possible area of spawning in this estuary is estimated to be less than 2,000 square yards. All spawnings so far observed have been very light (Table 1 intensity ratings) and the area suitable for spawning has not been utilized fully. The magnitude of egg deposition in the San Luis River estuary cannot account for the numbers of adult herring observed and caught near the mouth of the river and in the bay off Avila during the summer months. Apparently the adult population spawns in the more extensive eel grass beds in Morro Bay and, during the non-spawning period, schools in the Avila-Pismo Beach area, as well as in the Estero Bay region. Boats catching fish for live bait frequently find scattered adult herring along the entire coast from Point Sal to San Simeon during the summer period. Although only a few specimens have been recorded from this area, it is apparent from observations of fishermen and biologists that the herring attain a rela-

tively larger size here than in any other locality along the Californian coast.

Collections of herring in July, 1954, indicate that there may be additional herring spawning grounds in Santa Ynez Lagoon. Herring were reported to be landlocked in this lagoon and four beach seine hauls took both adult and juvenile herring. The lengths of 100 of these fish indicated that two or possibly three separate groups of juveniles were present. The bar across the mouth of the river was open to the sea during winter, closed in March, and reopened for a few weeks in early April from a flush of water from an upstream dam. It is not known whether the young fish were actually spawned in the lagoon or were spawned elsewhere and came in with the tidal waters and remained in the lagoon until the bar again closed. Two of the adults collected, a male and a female, were in late stages of maturity, which is not a natural condition for herring in summer. The temperature of the water in the lagoon in July ranged from 17.5 to 19.7 degrees C. (63.5 to 67.5 degrees F.). It seems probable that the smallest juveniles (30-44 mm., standard length) were spawned in the lagoon after the bar closed in April.

Moss Landing-Salinas River Area

The area suitable for spawning in Elkhorn Slough and possibly also in the Salinas River estuary is relatively limited in comparison with the Tomales Bay and San Francisco Bay regions. There is a scarcity of spawning substrate in Elkhorn Slough because of the extensive mud flat areas; only an occasional clump of eel grass *(Zostera)* and wire-grass *(Gracilaria)* is present, plus a few rock outcroppings near the mouth of the slough. The total available spawning area is estimated to be not over 3,000 square yards, and on all occasions when the area was surveyed only a small portion of the total available substrate was utilized by spawning herring.

All spawnings observed have occurred during the last week of January through February. Deposition of herring spawn has been noticeably sporadic in Elkhorn Slough from year to year. In 1952, and again in 1955, spawnings in the slough were of heavy intensity, whereas in 1953 and in 1954 only very light, scattered spawnings were located.

Juvenile herring remain in the immediate slough area and along the beach from Santa Cruz to Monterey. Juvenile herring have also been taken with beach seines during the summer in the landlocked brackish waters of the Salinas River. These juveniles were either spawned in the river estuary when the bar was open or came into the river from the ocean after they left the Elkhorn Slough area. No herring spawn has been located in the Salinas River, although no systematic observations have been made of this area during the spawning period.

Adult herring are found in considerable numbers in Monterey Bay from April through November. The limited spawning area in Elkhorn Slough is not large enough to accommodate a population of the size present in the Bay in summer, and most of these yearling and adult herring must come from either the Morro Bay or the San Francisco and Tomales bay spawning grounds. Up to 3,000 tons of adult herring were caught by purse seine and lampara boats in Monterey Bay during the summer of 1952. Reports from the fishermen indicate that much

more herring was available and that a greater tonnage could have been taken had there been a demand for it.

Recent sampling of bait boat catches and surveys of the M. V. YELLOWFIN indicate that Monterey Bay is one of the principal nursery grounds for young herring along the central California coast. From December through March only immature fish, one year or less in age, are taken in quantity by commercial and bait fishermen, although occasionally a small school of adults appears near the mouth of Elkhorn Slough. Juvenile herring have also been caught near the mouth of Bodega Bay, in Tomales Bay, and in San Francisco Bay. They also have been found scattered along the coast from San Francisco to Monterey. No herring have ever been caught between Monterey and San Simeon.

San Francisco Bay Region

Spawning has been observed from mid-December until the last of March in San Francisco Bay. In 1955 there were five major spawning periods in the Bay (Figure 8). The general areas of spawning in 1955 extended from Lime Point to Point Richmond, with the center of spawning around Belvedere peninsula and Angel Island. During past seasons, fishermen have reported that in the latter part of the season herring spawn as far as Point San Mateo in the South Bay. In 1955 there were reports of spawning at Hunters Point, but these were not confirmed. The five spawnings known to have taken place in San Francisco Bay and in neighboring San Pablo Bay in 1955 were the following.

The first occurred sometime during the 9th and 10th of January, over a very small area (about three-quarters of a linear mile of beach) on Belvedere peninsula, and the intensity of spawning was rated as light. As with most of the observations in California, the spawning activity took place at night and during a high tide period. The mortality of eggs in the zone two to three feet above mid-tide level was very high.

The second spawning took place from January 22 to 25. This was classified as medium in intensity and extended continuously along the shore line from Lime Point to Sausalito. Concurrent spawning took place on a portion of the shore line on Belvedere peninsula, and along a section of the beach on Angel Island near Point Stuart. It was estimated that spawn was deposited over approximately five linear miles during this three-day period.

The third spawning occurred on February 7th and covered only a few hundred yards of the rocky beach of Belvedere peninsula. Egg deposition was estimated to be very light. A series of eggs from this spawning was collected at frequent intervals by Mr. Fred Ludekens, a resident of Belvedere, and all had hatched by the eighth day. The mortality of eggs in the intertidal zone was very high, since only a few eggs per square foot could be found during the hatching period.

The fourth spawning was the heaviest and most widespread of the season. Approximately eight linear miles of light to heavy spawn was observed. This spawning extended over five days, February 10 through 14. After the 14th, no schools of herring could be found and apparently all the herring present in the spawning area had returned to sea.

This was the only spawning to occur on the Richmond or east side of the Bay throughout the 1955 spawning season. Scofield (1920) noted

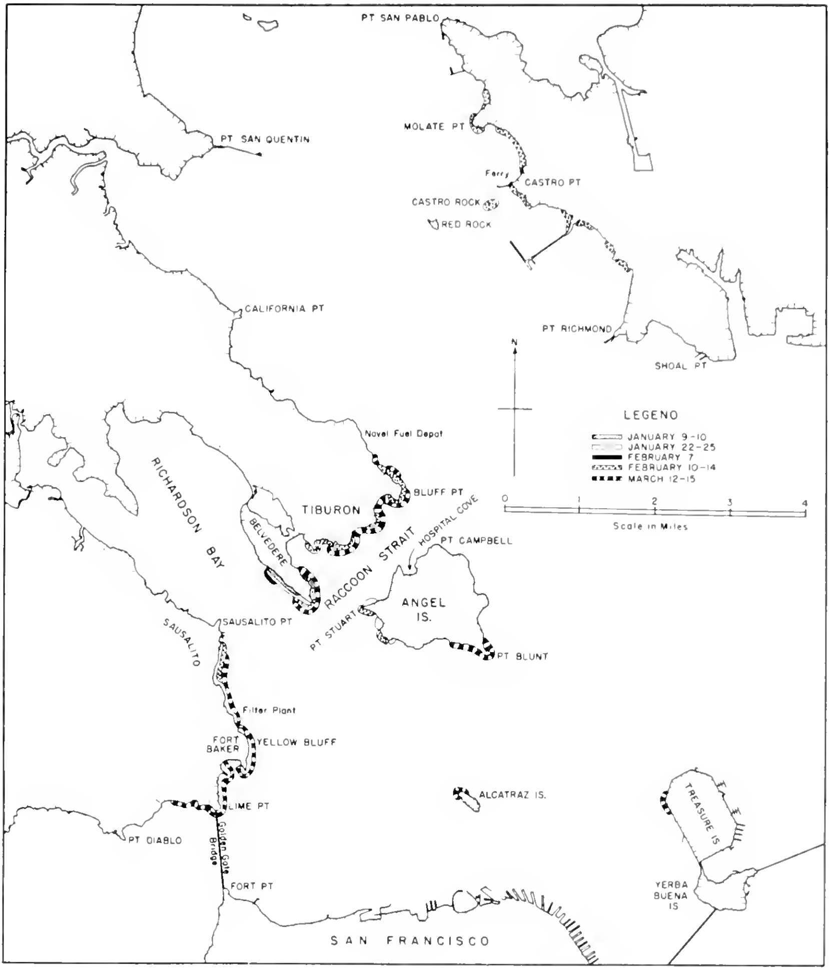

FIGURE 8. Spawning areas located in San Francisco Bay in the 1955 spawning period.

that herring spawned in the area around Point San Pablo and Point Pinole and that most of the 1920 San Francisco Bay catch was made in the San Pablo Bay area. Scofield attributed this change from the Raccoon Strait area to San Pablo Bay to the low winter runoff of the Sacramento and San Joaquin rivers, which permitted the salt water to move farther upstream than ever before recorded. Croker (1930) reported a very heavy spawning from February 9 to 11, 1930, in the area from Rodeo to the Carquinez Strait on the east side of the bay. In 1955, residents along the shore from Carquinez to Richmond were interviewed, and the information gathered indicates a gradual displacement of herring spawning toward the ocean since 1930. A spawning is reported to have occurred near Rodeo about six years ago, but none has been recorded since. In 1955, spawning extended into San Pablo

Bay as far north as Point San Pablo. A resident of Richmond has recorded the dates of herring spawning since 1941 (Table 2) and throughout this period herring spawned but once a year (except in 1949) on the east side of the Bay.

TABLE 2

Herring Spawning Dates at Richmond, California, From 1941 Through 1955

Year	Date	Year	Date
1941	March 6	1949	February 16 and March 14
1942	February 9	1950	February 19
1943	" 11	1951	" 23
1944	March 9	1952	" 8
1945	" 23	1953	" 3
1946	February 20	1954	" 4
1947	" 8	1955	" 10
1948	January 24		

The fifth 1955 spawning took place about March 15-22. This spawning was not surveyed as intensively as the earlier ones, but observations made from shore and the M. V. NAUTILUS indicated that seven linear miles of beach were covered by a light to medium spawning. During this period, spawning shifted toward the south San Francisco Bay area and considerable bird activity was reported on Alcatraz and Treasure islands.

The survey terminated in San Francisco Bay on March 22, and since some schools of unspawned herring were still present in the area, it is likely that another spawning took place after that date. Interviews with residents and fishermen failed to reveal the area and extent. This last spawning was probably very limited and of little consequence. The 1955 herring spawnings in the San Francisco Bay area are summarized in Table 3.

TABLE 3

Herring Spawning in San Francisco Bay in 1955

Spawn no.	Date	Area	Linear yards	Intensity
1	Jan. 9-10	Belvedere peninsula	1,500	light
2	Jan. 22-25	Sausalito, Belvedere, Angel Island	4,800	medium
3	Feb. 7	Belvedere peninsula	200	very light
4	Feb. 10-14	Sausalito, Belvedere, Tiburon, Richmond	13,100	heavy
5	Mar. 15-22	Sausalito, Belvedere, Tiburon, Treasure Island	12,000	medium?
Total			31,600	

Tomales Bay Area

The spawning areas in Tomales Bay in 1955 were confined, for the most part, to the eel grass and kelp beds, although some spawning occurred on gravel and rocky beaches near the southern portion of the Bay (Figure 9). In comparison with San Francisco Bay, the widths of the spawning areas are quite narrow and restricted. Extensive areas

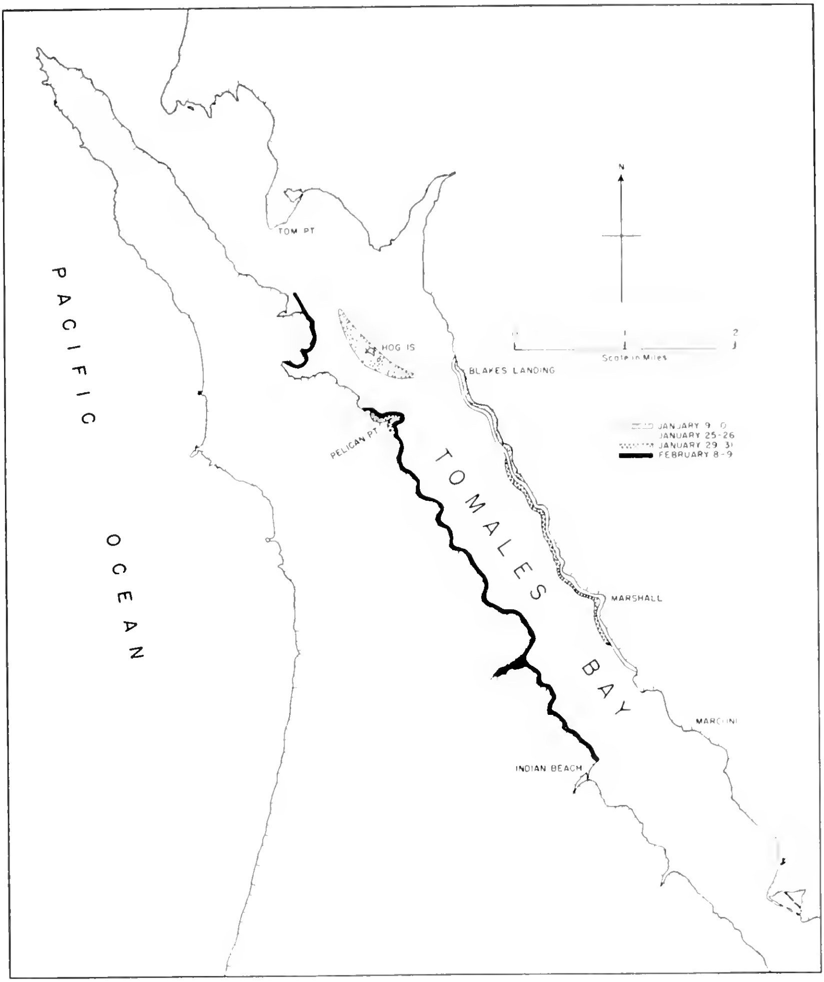

FIGURE 9. Spawning areas located in Tomales Bay in the 1955 spawning period.

of eel grass are present in the Bay between Tom Point and Hog Island, yet only a small amount of spawning has been recorded in this area.

As in San Francisco Bay, there were five known spawning periods in Tomales Bay in 1955. The first took place on January 9th and 10th and extended from Blake's Landing southward along the east shore line about 2,000 yards. This spawning was of very light intensity. The eggs were deposited mainly on eel grass below the low tide level. Some spawn also was deposited on rocks at several points in the intertidal zone.

The second spawning occurred on January 25th and 26th and also was estimated to be light. The area of deposition was on the east side of the Bay and extended from Blake's Landing to roughly a mile south

of Marshall, a total linear distance of about 5,500 yards. This light spawn was fairly evenly concentrated over all the available substrate along the shore.

The third spawning occurred several days after the second and eggs of both spawnings were found on the same substrate along several linear miles of the east shore. This spawning extended toward the mouth of the Bay and covered a considerable area of the eel grass and kelp beds near Hog Island and Pelican Point. Of light intensity, it was estimated to cover 5,000 linear yards.

The fourth spawning was the most extensive to take place in Tomales Bay in 1955. It occurred on the west shore line and covered approximately 8,800 linear yards. This spawning was rated of medium intensity. Bird activity was very heavy and gulls were present by the thousands.

The fifth spawning took place during the 28th of February and the first of March. The area was not surveyed during this period but local fishermen and residents reported only limited spawning on the west shore line.

A summation of the herring spawnings in 1955 in Tomales Bay is presented in Table 4.

TABLE 4

Herring Spawning in Tomales Bay in 1955

Spawn no.	Date	Area	Linear yards	Intensity
1	Jan. 9-10	East shore near Blake's Landing	2,000	very light
2	Jan. 25-26	East shore Blake's Landing to Marconi	5,500	light
3	Jan. 29-31	East shore Hog Island to Marconi	5,000	light
4	Feb. 8-9	West shore Hog Island to Indian Beach	8,800	medium
5	Feb. 28-Mar. 1	West? shore	?	very light
Total			21,300	

POPULATION ESTIMATES

Due to the complexity of the different herring spawning areas in California, a considerable amount of time was spent in developing methods of fish sampling and spawn censusing. Fortunately, spawning in Tomales Bay was spaced at convenient intervals and the spawn was deposited in areas easy to sample. It is believed that the data derived from this study area may be compared with a fair degree of accuracy to the population estimate studies conducted by Canadian research biologists.

The San Francisco area was much more complex and too much effort was placed on echo sounding, resulting in a poorer estimate of spawn deposition than could have been obtained. In order to survey adequately the amount of spawn in San Francisco Bay, a series of deep hauls would have to be made over the entire shore line to a depth of about 50 feet below mean low tide. It is not known how much spawn is deposited below the low tide level in San Francisco Bay, for only a few deep drags (for rocks and shell fragments) were made. On several occasions, eggs were found in the deeper water adjacent to the beaches

where herring spawn was located. The only measure of the amount of spawning taking place in San Francisco Bay is that of the linear yardage of each spawning. Hourston (personal communication), however, has indicated that linear measurements made in one year may be compared to similar measurements made in the same area in other years. In Canada, surveys have been conducted to determine an "average width" of herring spawn along the beaches and the results indicate that most spawnings average 20 yards. This figure compares favorably with the estimates of the width of the spawning substrate along the shores of Tomales Bay, but it is believed that the average width of most spawning areas in San Francisco Bay may be somewhat greater. Also, the linear measurements in California included the entire shore line of a given area, although spawning localities were not uniformly distributed over the area. The linear measurements thus presented are maximum estimates and probably are higher than the true values.

Spawning intensities were based, however, on the same techniques and intensity scales as were used in Canada, and the estimates of population size made by Hourston (1953) are here used to obtain a general estimate of the San Francisco Bay and Tomales Bay herring population in 1955. By extensive sampling Hourston developed a scale of square yards of spawning and number of eggs per square yard according to each of his four intensity categories (Table 5). Using the number of

TABLE 5

Number of Eggs Per Square Yard at Different Intensities of Spawn Deposition (From Hourston, 1953)

Intensity	Number of eggs in one square yard
Very light	7,000
Light	246,000
Medium	1,009,000
Heavy	1,369,000

eggs per square yard, the number of eggs spawned per female, and the sex ratios of the fish present, and making the necessary corrections for omitted areas, Hourston estimated that 18,000 tons of herring participated in the spawning in the coastal section he studied. He also gave the total number of square yards in the study area and this can be converted into linear measurement by dividing by 20 yards (the average width of spawning), which gives approximately 40,700 linear yards of spawn deposition in the Canadian study area.

There were 31,600 linear yards of spawning in San Francisco Bay (Table 3) and at least 21,300 linear yards in Tomales Bay (Table 4) during the 1955 season. This would indicate that the combined populations spawning in Tomales Bay and San Francisco Bay exceeded the population in the Canadian test area. Nearly all the spawning in Canada, however, was of medium and heavy intensity, whereas in California most of the spawning intensities were very light to medium. Thus, the linear yardage figures are not directly comparable and the numbers of fish spawning per square yard in Canada were much greater than in the Californian areas.

Although the Californian data are based on insufficient and inadequate samples, we have used Hourston's figures as a basis for calculating the Californian population because of similarities in the spawning substrate in the two regions. Hourston's estimates of eggs per square yard according to each spawning intensity category were multiplied by the number of square yards of spawning in San Francisco and Tomales bays (Table 6). These calculations give a total of 705,110 million eggs in San Francisco Bay and 229,524 million in Tomales Bay. Hourston's computations indicated that 1,056,500 million eggs were produced by 18,000 tons of herring. Based on this ratio of eggs produced per ton of fish, approximately 12,000 tons of herring utilized the spawning grounds in San Francisco Bay and 4,000 tons in Tomales Bay, a total of 16,000 tons. Obviously, these are exceedingly rough comparisons and they merely give a gross approximation of the size of the central Californian herring population. They are, however, the best that can be produced with the data at hand. One of the complicating factors is that the herring in the Canadian study area were of larger size than those in California and that each female would deposit more eggs per spawning. More herring would be required in California to produce the same number of eggs and we would have an underestimate of the numbers in the Californian population. On the other hand, the Californian fish, being smaller, would not produce as great a tonnage and these two errors tend to compensate in the tonnage estimates here given.

TABLE 6

Calculation of Number of Herring Eggs Spawned in San Francisco and Tomales Bays in 1955, Based on Canadian Measures of Eggs Per Square Yard

Intensity	Canada	San Francisco Bay			Tomales Bay		
	Eggs per square yard	Linear yards	*Square yards	No. eggs	Linear yards	*Square yards	No. eggs
Very light	7,000	200	4,000	28,000,000	2,000	40,000	280,000,000
Light	246,000	1,500	30,000	7,380,000,000	10,500	210,000	51,660,000,000
Medium	1,009,000	16,800	336,000	339,024,000,000	8,800	176,000	177,584,000,000
Heavy	1,369,000	13,100	262,000	358,678,000,000			
Total				705,110,000,000			229,524,000,000

* Linear yards multiplied by 20.

CONCLUSIONS

The data presented here demonstrate that the population of Pacific herring in central and southern Californian waters is of relatively small magnitude compared to the populations in Canada, where from 100 to 200 thousand tons of herring are taken annually. The entire spawning population utilizing San Francisco and Tomales bays approximated only 16,000 tons.

There was no apparent change in the age and length composition of the Tomales Bay population after the largest recorded catch (approxi-

mately 5,000 tons in 1952). Most of this catch (3,000 tons) was made in Monterey Bay.

Most of the adult summer population in Monterey Bay consists of herring that utilize the spawning areas in Tomales and San Francisco bays.

Critical examination of eggs attached to crab traps set in offshore waters down to 30 fathoms, and the lines attached thereto, revealed that they were definitely not herring eggs, thus strengthening the supposition that Californian herring spawn only in the intertidal zones of bays and estuaries.

Herring spawnings in California are sporadic from year to year, resulting in fluctuating populations in the smaller spawning areas. Only in San Francisco and Tomales bays is there evidence of a sizable population upon which a permanent fishery could be conducted.

Without further study it would be difficult to set a limit of catch that could be taken safely in these two bays. If a take for reduction is allowed, there should also be some sort of control of the catch for other purposes, including the take for pet food and human consumption.

The pre-spawning schools are concentrated in a small area and are completely available to boats using round haul nets, especially in Tomales Bay. The possibility exists that the industry might find a ready use for herring when no other pelagic fish are available for pet food, bait, and human consumption. Should such increased catches take place in addition to otherwise "safe" reduction permits, the herring conceivably could be overfished in a short time.

SUMMARY

1. Pacific herring in California are available on the spawning grounds during January, February, and March, and are available during the summer months in Monterey Bay and in the Avila-Morro Bay area.
2. Herring in California grow faster during their first year than do herring in Alaska and Canada. After their third year the northern herring grow more rapidly. The northern fish also live longer and attain a larger size. Herring 19 years old have been reported from Alaska, whereas the oldest individual collected in California was nine.
3. The composition of the 1955 commercial catch consisted mainly of two- and three-year-old fish (1953 and 1952 year classes) in the Tomales Bay beach seine fishery and of five- and six-year-old fish (1950 and 1949 year classes) in the San Francisco gill net fishery. The gill net fishery of San Francisco utilizes only the largest fish in the population.
4. Indications are that Pacific herring mature at an earlier age in Californian waters than do those to the north. Twenty-two percent of the 1955 Tomales Bay spawners were two years old, whereas only 2.5 to 9.8 percent of the total catch of pre-spawning herring off Vancouver Island consisted of two-year-olds during the period from 1946-1951.
5. Pre-spawning herring enter the bays and estuaries along the coast of California a week or more before spawning. These pre-spawning

schools remain in close proximity to the future spawning areas and are highly available to fishing activities during this period.

6. Pre-spawning adult herring are not attracted to a light suspended over the surface of the water, as are sardines, mackerel, and anchovies.
7. Herring eggs on the San Francisco Bay and Tomales Bay spawning grounds hatched in from 6 to 11 days after spawning in temperatures ranging from 8 to 10 degrees C. (46.4 to 50.0 degrees F.).
8. Herring spawnings in San Francisco Bay were greater in intensity and extent than the spawnings in Tomales Bay and the spawning population of herring in San Francisco Bay is estimated as roughly three times that in Tomales Bay.
9. Five known spawnings took place in both Tomales and San Francisco bays in 1955. A sixth spawning probably occurred in each area late in the season, but these were not studied.
10. The echo-sounding technique of population estimation proved unsuccessful in San Francisco Bay, because of erratic movements of the pre-spawning herring schools in the fast moving tidal waters of the Bay.
11. Experimental tows were made with a three-foot diameter, high-speed net. All attempts to obtain an adequate sample were unsuccessful.
12. Intensity studies were conducted on the Tomales Bay and San Francisco Bay spawning grounds in 1955 and the results were compared with a study conducted in Canada. This comparison indicated that a population approximating 12,000 tons utilized the San Francisco Bay spawning grounds and one approximating 4,000 tons the Tomales Bay spawning grounds.

REFERENCES

Carson, Rachel L.
1943. Food from the sea: fish and shellfish of New England. U. S. Fish and Wild. Serv., Cons. Bull. 33, 74 p.

Croker, Richard S.
1930. Herring in Carquinez Straits. *In*: Commercial Fishery Notes. Calif. Fish and Game, vol. 16, no. 2, p. 188.

Hart, John Lawson, and Albert L. Tester
1934. Quantitative studies on herring spawning. Amer. Fish. Soc., Trans., vol. 64, p. 307-312.

Hourston, A. S.
1953. Estimation of herring population size by means of echo-sounder tracings and its application to herring research. Fish Res. Bd., Canada, Circ. 26, 18 p.

Radovich, John, and Earl D. Gibbs
1954. The use of a blanket net in sampling fish populations. Calif. Fish and Game, vol. 40, no. 4, p. 353-365.

Rounsefell, George A.
1930. Contribution to the biology of the Pacific herring, *Clupea pallasii*, and the condition of the fishery in Alaska. U. S. Bur. Fish., Bull., vol. 45, p. 227-320.

Scofield, N. B., ed.
1920. Low rivers influence spawning habits of herring. *In*: Commercial Fishery Notes. Calif. Fish and Game, vol. 6, no. 2, p. 81.

Scofield, W. L.
1952. The Tomales Bay herring fishery. Calif. Fish and Game, vol. 38, no. 4, p. 499-504.

Stevenson, J. C.
1950. Results of the West Coast of Vancouver Island herring investigation, 1948-49. Brit. Columbia, Prov. Dept. Fish., Rept. for 1948, p. 37-85.

Stevenson, J. C., A. S. Hourston, and J. A. Lanigan
1951. Results of the West Coast of Vancouver Island herring investigation, 1950-51. Brit. Columbia, Prov. Dept. Fish., Rept. for 1950, p. 51-84.

Tester, A. L., and J. C. Stevenson
1947. Results of the West Coast of Vancouver Island herring investigation, 1946-47. Brit. Columbia, Prov. Dept. Fish., Rept. for 1946, p. 42-71.

AN UNDESCRIBED TYPE OF MIGRATION IN KING SALMON, *ONCORHYNCHUS TSHAWYTSCHA* (WALBAUM)[1]

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INTRODUCTION

A king salmon of spawning size, after going many miles into fresh water, returned to the ocean instead of proceeding upstream to spawn. This salmon was tagged in the Sacramento River 76 miles[2] above its mouth, 80 miles into fresh water and 126 miles from the Golden Gate. Two hundred and twenty-six days later it was caught by a sportsman near the Farallon Islands, about 30 miles off San Francisco. This was so different from the behavior we expected that the fish soon became known as the "wrong way" salmon; indeed, I am unaware that there is any record of such an occurrence.[3]

THE OCEAN RECOVERY

The king salmon that returned to the ocean was tagged September 24, 1953, near Fremont Weir.[4] Thousands of others have been tagged at the same location in a population study. The fish were caught in cylindrical wire fyke traps about 10 feet in diameter. These traps were set in a series near the downstream end of Fremont Weir and were roughly two miles above the mouth of the Feather River. Each fish was tagged at the trap in which it was caught.

The "wrong way" salmon was caught May 8, 1954, by Mr. Emil Feltre, who was fishing on the party boat EDIBOB, operated by Captain Carl Bianchi. They were fishing in the Pacific Ocean near the Farallon Islands, 155 miles from Fremont Weir. This fish was 68 cm. (26.8 inches) long from the tip of the snout to the fork of the tail when it was tagged. No comparable measurements were made when it was retaken.

Dr. Gilbert M. Smith of Stanford University identified algae growing on the tag as *Ectocarpus* sp., a marine form. Dr. Smith said the colony of algae had been growing for a considerable time.

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[1] Submitted for publication June, 1955.
[2] Distances are river miles; i.e., statute miles measured along the main channel.
[3] It is a relatively common occurrence for king salmon in fresh water to drop a short distance downstream in order to spawn or to ascend a tributary. For example, many salmon tagged in the same area as the "wrong way" salmon have dropped downstream about two miles and entered the Feather River.
[4] Fremont Weir is a long spillway on the west bank of the Sacramento River. It allows flood waters to spill out of the river channel into the Yolo Bypass.

DOWNSTREAM RECOVERIES OF FISH TAGGED AT FREMONT WEIR

In the years 1950-53 there were 36 recaptures (Figure 1 and Table 1) of king salmon that may have been following the route of the "wrong way" salmon. These recaptures were made at distances ranging from 36

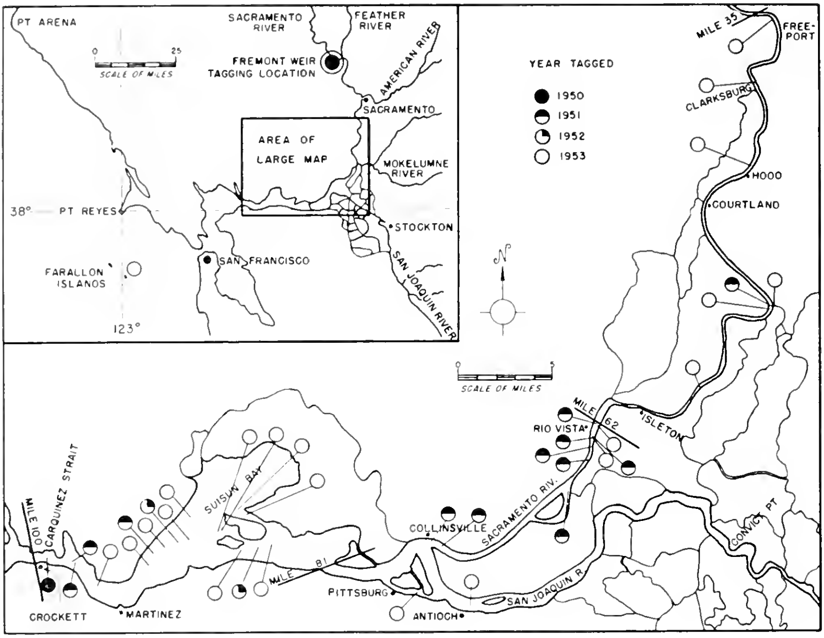

FIGURE 1. Delta area of the Sacramento-San Joaquin rivers, showing localities for downstream recoveries of king salmon tagged at Fremont Weir. (Upper limits of gill net fishing: 1950, mile 62 and Convict Point; 1951, same; 1952, mile 81; 1953, mile 81. Lower limit for all years: mile 100.)

to 98 miles below the Fremont Weir tagging area. Seventeen of the 36 fish were taken in brackish water of more than one-third the salinity of the open ocean.

Thirty-five other king salmon from Fremont Weir were taken a shorter distance downstream or appeared to be on their way to spawn either in a lower tributary of the Sacramento River or in some tributary of the San Joaquin River. Although these fish moved downstream, they have not been included among those whose behavior suggests a migration back to salt water. The 35 may be classified in three groups:

(1) Twenty-eight retaken in the Feather River drainage or near its mouth, 2 miles downstream from Fremont Weir.

(2) Three retaken in the American River or near its mouth, 21 miles downstream from Fremont Weir.

(3) Four retaken in the Mokelumne River.

TABLE 1

King Salmon Tagged at Fremont Weir and Retaken More Than 35 Miles Downstream

Fork length when tagged, in cm.	Date tagged	Date recovered	Days at liberty	Miles traveled	Miles per day	Method of recovery	Locality of recovery
1950							
90	8/21	9/21	34	98	2.9	Gill net	Carquinez Strait
1951							
57	8/31	9/7	7	65	9.3	Gill net	Rio Vista
55	8/31	9/19	19	75	4.0	" "	Collinsville
57	9/6	9/11	5	66	13.2	" "	Rio Vista
57	9/9	9/23	14	92	6.5	" "	Suisun Bay
55	9/10	?	?	94	?	" "	Carquinez Strait
68	9/11	9/21	10	69	6.9	" "	Rio Vista
60	9/11	Before 9/26	< 15	92	?	" "	Suisun Bay
54	9/13	9/19	6	65	10.8	" "	Rio Vista
62	9/13	9/17	4	75	18.8	" "	Collinsville
64	9/15	9/20	5	65	13.0	" "	Rio Vista
56	9/15	9/18	3	65	21.7	" "	" "
86	9/19	9/22	3	48	16.0	Found dead	Walnut Grove
1952							
49	8/1	9/2	32	87	2.7	Gill net	Suisun Bay
57	9/10	9/19	9	83	9.2	" "	" "
1953							
39	8/5	8/26	21	87	4.1	Gill net	Suisun Bay
48	8/7	8/26	19	87	4.5	" "	" "
80	8/21	?	?	55	?	Angling	Rio Vista
62	8/25	8/29	4	50	12.5	"	Walnut Grove
59	9/1	9/12	11	71	6.5	Found dead	Antioch
49	9/8	9/20	12	64	5.3	Angling	Rio Vista
49	9/9	9/24	15	87	5.8	Gill net	Suisun Bay
50	9/9	9/14	5	95	19.0	" "	Carquinez Strait
50	9/10	9/16	6	83	13.8	" "	Suisun Bay
45	9/11	9/16	5	87	17.4	" "	" "
55	9/14	9/23	9	83	9.2	" "	" "

TABLE 1—Continued

King Salmon Tagged at Fremont Weir and Retaken More Than 35 Miles Downstream

Fork length when tagged, in cm.	Date tagged	Date recovered	Days at liberty	Miles traveled	Miles per day	Method of recovery	Locality of recovery
1953—Continued							
53	9/15	9/20	5	92	18.4	" "	" "
46	9/15	9/22	7	92	13.1	" "	" "
44	9/18	9/23	5	87	17.4	" "	" "
62	9/18	10/3	15	45	3.0	Angling	Hood
52	9/18	9/27	9	83	9.2	"	Suisun Bay
61	10/1	10/31	30	36	1.2	Illegal gear	Freeport
56	10/23	10/31	8	48	6.0	Angling	Walnut Grove
55	10/29	11/5	7	39	5.6	"	Clarksburg
60	11/12	12/6	24	77	3.2	Found dead	Pittsburg
87	12/10	12/29	19	64	3.3	Angling	Rio Vista
1953—Recovered in the ocean in 1954							
68	9/21	5/8/54	226	155	0.7	Angling	Farallon Islands

SALMON RECOVERED THE YEAR AFTER TAGGING

If many salmon tagged at Fremont Weir had returned to the ocean and remained till the following season, some should have been caught a year or more later. Reports are on hand of three salmon retaken the season after tagging. In each case there may be an error.

The most convincing of these reports was made by the Department's tagging crew at Fremont Weir. On October 26, 1953, they caught a king salmon bearing tag number K-6043. This fish had been released at the same spot on September 9, 1952. The tagging crew did not recognize the unusual nature of the recovery until after the fish with the old tag in place had been released. There is a slight chance that they incorrectly read or recorded this tag number.

A fish, retaken at Coleman Fisheries Station [5] after more than a year of liberty, had been recorded as a king salmon when tagged. The hatchery man reported the fish as a steelhead and saved the tag but not the fish. It is almost unheard of for either group of men to mistake salmon and steelhead but in this case one group did. Steelhead frequently spawn in two consecutive years.

The third report of such a recovery, while proven considerably in error, cannot be completely disproved.

SIZE OF THE DOWNSTREAM MOVEMENT

The size of the downstream movement may be seen if the number of downstream recoveries is compared with the total number of tags recovered. In this paper, a "downstream recovery" is a king salmon tagged at Fremont Weir and retaken 35 miles or more downstream. We have 36 such recoveries; these are more than 5 percent of all the recoveries from the 5,774 king salmon tagged at Fremont Weir. This proportion was very high during some short periods: over 40 percent for fish tagged during one fortnight in 1951, and over 30 percent for those tagged during another fortnight in 1953.

The fall gill net fishery—August 10 to September 26—is the largest and most reliable source of the downstream recoveries. All the Fremont Weir king salmon recovered by this fishery were released between August 1 and September 18. When we limit the comparison to salmon tagged during that time we find that 15 percent of the returns, or 1.2 percent of all the fish tagged, were retaken in gill nets more than 62 miles below Fremont Weir.

In California's salmon fisheries most tagged fish escape capture. This is true of the gill net fishery, which caught most of the downstream recoveries. In the years 1946-50, 800 king salmon were tagged and released during the fall season in the gill net fishing area. Of these, one out of every 6.61 was retaken by gill nets between Rio Vista and Carquinez Bridge (62 and 100 miles below Fremont Weir), and one out of every 11.4 by gill nets between Stake Point and Carquinez Bridge (81 and 100 miles below Fremont Weir).

We can estimate the number of tagged salmon from Fremont Weir present in these two areas by multiplying the number of downstream

[5] Coleman Fisheries Station of the U. S. Fish and Wildlife Service is located on Battle Creek, tributary to the Sacramento River, 201 miles above the Fremont Weir tagging area.

recoveries in the area by the appropriate factor—6.61 or 11.4. These estimates of numbers can be expressed in percentages of salmon tagged at Fremont Weir (Table 2).

TABLE 2

King Salmon Tagged at Fremont Weir and Retaken in Gill Nets

Area of recapture	Year	Number tagged	Number retaken	Tagged salmon present* in areas of recapture	
				Number	Percentage of number tagged
(Tagged 8/1-9/18; retaken 8/10-9/26)					
62-100 miles down (factor 6.61)	1950	11	1	7	60
	1951	181	11	73	40
81-100 miles down (factor 11.4)	1950	11	1	11	100
	1951	†173	3	34	20
	1952	265	2	23	9
	1953	1,526	10	114	7
(Tagged 9/9-9/15; retaken 9/14-9/26)					
62-100 miles down (factor 6.61)	1951	101	8	53	52
81-100 miles down (factor 11.4)	1951	†96	3	34	36
	1952	33	1	11	33
	1953	369	7	80	22

* Estimated by multiplying the "number retaken" by the factor given under "area of recapture". The number tagged in 1950 was so small that the extensions may be misleading. For other limitations of these estimates see the text.

† Adjusted by subtracting salmon caught between 62 and 81 miles downstream.

After September 22, 1951, fishing with gill nets was illegal above Stake Point. No correction has been made for the shorter season between Stake Point and Rio Vista in 1951. In 1952 and 1953 no estimates were possible for the area lost to gill net fishing.

The numbers of salmon which the crew tagged at Fremont Weir increased each year from 1950 to 1953 (Tables 3 and 4). In 1951 tagging began 26 days later than in 1953. The estimated proportion of salmon moving downstream cannot be directly compared in these two years.

Sixteen of the 24 salmon recaptured in gill nets were tagged between September 9 and September 15, a seven-day period. This peak occurred in both 1951 and 1953. In 1952 one of the two salmon recovered downstream was tagged within this week. In 1950 only two salmon were tagged after September 9. The peak may indicate the period when salmon, moving down from Fremont Weir, are exposed to the greatest chance of capture. There is nothing to show that this is due to a greater downstream movement between September 9 and September 15. The fish tagged at this time do offer the best comparative measure of the apparent maximum size of the downstream movement for each of three years.

TABLE 3

King Salmon Tagged at Fremont Weir Between August 1 and September 18, 1950-53

Date	1950	1951	1952	1953	Totals
8/1			6	--	6
2			--		--
3			--	27	27
4			6	30	36
8/5			5	12	17
6			7	27	34
7			11	27	38
8			7	--	7
9			6	--	6
8/10			6	23	29
11			6	29	35
12			5	13	18
13			7	23	30
14	1		7	18	26
8/15			6	24	30
16	3		4	12	19
17			4	24	28
18			6	27	33
19			6	17	23
8/20			4	10	14
21	2		2	23	27
22	1		1	--	2
23	1		4	--	5
24			3	24	27
8/25			3	31	34
26			2	19	21
27			1	46	47
28			3	39	42
29		1	3	43	47
30			6	36	42
8/31		4	6	34	44
9/1			5	16	21
2			4	11	15
3			6	39	45
4			6	55	61
9/5		4	6	--	10
6		5	5		10
7	1		5		6
8		6	6	40	52
9		14	2	81	97
9/10		13	1	56	70
11		6	2	54	62
12		7	3		10
13	2	13	9	--	24
14		23	7	74	104
9/15		25	9	104	138
16		27	6	69	102
17		11	15	85	111
9/18		22	25	144	191
Totals	11	181	265	1,526	1,983

Limitations of the Estimates

Several limiting factors apply to the estimates given in Table 2.

1. *They apply only to the smaller king salmon.* Sampling of the gill net catch has shown that the gill nets take salmon averaging about 90 cm. (35.4 inches), fork length. The 1,982 king salmon tagged at Fremont Weir between August 1 and September 18 averaged 52.8 cm. (20.8 inches), fork length. This is equivalent to 22.7 inches in total length. All but 11 of these fish were taken in the wire fyke traps; this type of gear selects smaller king salmon.

TABLE 4

King Salmon Tagged at Fremont Weir, by Month, 1950-53

Year	Month								
	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
1950	0	0	7	8	14	217	2	0	248
1951	0	0	0	5	415	301	4	0	725
1952	14	33	29	143	356	379	11	0	965
1953	0	0	91	667	1,756	1,004	234	84	3,836
Totals	14	33	127	823	2,511	1,901	251	84	5,774

The downstream recoveries were slightly larger than the average of all tagged fish. They averaged 57.0 cm. (22.4 inches) in fork length, and they ranged in size from 39 cm. (15.4 inches) to 90 cm. (35.4 inches). The gill nets have a better chance of catching large salmon than small. The Fremont Weir fish are small. Therefore, the efficiency of tag recovery for Fremont Weir tags may have been less than that for tags recovered during 1946-50.

2. *The estimates include only fish that were in the gill netting area during the open season.* Some salmon from Fremont Weir may have passed through the gill net fishing area before fishing began on August 10 or after it ended on September 26. We have no way of knowing how many such fish there may have been.
3. *The chance of catching a tagged fish in 1952 and 1953 may have been greater than estimated.* In these years more boats fished in the reduced fishing area. The area was crowded before the change and the added boats seem unlikely to have increased the efficiency of the fishing fleet.
4. *The salmon that moved down may not have spent the same time in the fishing area as those that were used to measure the chance of recapture.* Those that moved down may have passed through the area twice: once on the way down and once on the way back; they may have stopped moving when water of a certain salinity was reached; or, they may have behaved in still other ways. Salmon from Fremont Weir carried tags during their entire stay in the fishing area, while the salmon that were used to measure the chance of recovery were tagged after they had been in the area for a while.

The important limitations of the estimates in Table 2 tend to compensate each other. Some would make the estimates larger and others would make them smaller.

OTHER RECOVERIES

Twelve tagged king salmon were taken more than 40 miles downstream by means other than gill nets. Three were found dead: one in 1951 at Walnut Grove and two in 1953 near Pittsburg and Antioch. One was seized by wardens from illegal gear near Clarksburg in 1953. Eight were taken by sportsmen in 1953—most of them on bait used

by striped bass fishermen. In the years 1950-52 no downstream returns were made by sportsmen. The eight returns in 1953 resulted from 3,836 tagged salmon. At the same rate, four returns should have resulted from the 1,938 salmon tagged in 1950-52.

The returns by anglers using bait indicate that these salmon might have been actively feeding in fresh water. Rich (1921) watched adult king salmon feeding on smelt in the Cowlitz River and caught a 25-pound female on April 14, 1916. The Cowlitz empties into the Columbia River nearly 70 miles above its mouth. He assumed that the fish were on their spawning migration, and he says, "In the particular instance herein described, a normal food supply was present, with the result that the fish fed in a normal manner." He makes no suggestion that they might go back down the Columbia.

SEX AND MATURITY

Both sexes occurred among the king salmon migrating downstream. The four reports giving the sex of the fish are not enough to establish the sex ratio. None of the people reporting suggested that the gonads of the recaptured salmon were abnormal. All the salmon taken in the gill net fishery were cleaned by experienced fish handlers. A few of the fish were inspected by the salmon samplers on our staff. In 1951 I interviewed many of the men who caught or cleaned these fish and all said that the salmon were not different in appearance from the untagged salmon caught at the same time and place. None of these people reported finding a spawned out salmon, tagged or untagged, in the gill net catch. We have no reason to believe that any of these downstream migrants had ever spawned.

SALINITY

Sacramento River waters are fresh or nearly so for about 80 miles below Fremont Weir. Below that point the salinity rises rapidly. During 1950-53 the Sacramento-San Joaquin Water Supervision maintained five salinity observation stations between Port Chicago and Crockett—85 to 99 miles below the tagging area. During August and September of those years, the salinity at the five stations averaged about half that of the open ocean. None of the stations averaged less than one-third the salinity of the ocean.

RATE OF MOVEMENT

These salmon apparently moved downstream at rates ranging from 1.2 to 21.7 miles a day—average 9.5 (Table 1). This calculated average rate may be faster than the true rate since the gill net fishery, the best method of recapture, ends at the height of the run, allowing the fish moving more slowly a better chance to escape.

SEASON

All the salmon that were retaken downstream were tagged between August 1 and December 10. Too few salmon were tagged outside that time to create a favorable chance of a downstream return.

DESTINATION

Where do these king salmon moving down from Fremont Weir go? How many of them reach the ocean? Where did they spawn? Salmon tagged at Fremont Weir have never been taken in streams outside the Sacramento-San Joaquin Valley. This suggests that the downstream migrants spawned in that river system.

We have seen that many king salmon from Fremont Weir returned down the river to the gill net fishery. These "wrong way" salmon may have gone farther, perhaps even to the ocean, as one did. If many had done so, most must have returned to spawn in the Sacramento-San Joaquin Valley by early spring. Had they not, more should have been taken later, when fishing became intense in the ocean and the river.

CONCLUSIONS

From 1950 to 1953 many of the smaller adult king salmon in the Sacramento River during August and September returned downstream to brackish water, 80 miles or more. As many as one out of four fish present at Fremont Weir between September 9 and September 15 may have made this journey. This downstream movement occurred from August 1 to December 10 or longer. Most of those that went down must have gone back up the Sacramento River to spawn in the late fall and winter. One tagged salmon returned to the Pacific Ocean and stayed there until its capture the following May. It is not unreasonable to suppose that other individuals have made similar movements.

REFERENCES

California Department of Public Works

1951. Report of Sacramento-San Joaquin Water Supervision for 1950. Calif. Dept. Public Works, Div. Water Res., 187 p.

1952. Report of Sacramento-San Joaquin Water Supervision for 1951. *Ibid.*, 193 p.

1953. Report of Sacramento-San Joaquin Water Supervision for 1952. *Ibid.*, 209 p.

1954. Report of Sacramento-San Joaquin Water Supervision for 1953. *Ibid.*, 211 p.

Rich, Willis H.

1921. An instance of adult, sea-run chinook salmon found feeding in fresh water. Calif. Fish and Game, vol. 7, no. 1, p. 7-8.

SINGLE-GATE DEER TRAP[1]

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The standard double-gate deer trap described by Clover (1954) has proved superior to other types used in California to date. Continuing experimentation by the author has resulted in a modified single-gate trap with more efficient operating characteristics.

Construction details are presented in Figure 1 and needed materials are listed in Table 1.

The present model has been reduced in length by 18 inches, to confine the animal more closely. This reduces the force the animal can exert against the ends of the trap, cutting down on the possibility of injury or escape. An additional safety feature is the placement of the gate runner bars on the outside of the opening, which reduces the possibility of the animal catching its head between the runner bars and the side frame.

The tripping mechanism has been changed. Instead of using a trip thread actuated by the legs of a deer, the thread is fastened to a piece of white salt-stock block which is of sufficient weight to trip the rat-trap trigger when the salt is muzzled from the wooden block upon which it is placed. Alfalfa hay is placed around the wooden block to hide it, but not so high or solid as to prevent tripping the mechanism. After a deer is caught, the salt should be replaced with a new piece or the original piece washed thoroughly.

The catch-net support hooks should be constructed of 14-gauge galvanized wire, doubled and tied to the top frame between the runner bar and the side frame. Any surplus over 14 inches should be cut off and the sharp ends wrapped with friction tape to protect the webbing. The catch net should be hung so that it centers with the opening.

Rapid handling of a trapped deer is important. Not more than 10 seconds should elapse between the time the handler reaches the trap and the time the deer is bundled up in the catch net. Delay in this operation may result in the deer falling from exhaustion, making netting an impossibility.

It is best to ear tag or otherwise mark antlered bucks while they are still in the trap. The antlers may hook the side of the catch net during the netting operation, with the resulting loss of an animal. A buck should be worked upon from outside the trap.

The trap site should be cleaned carefully after each catch and fresh dirt placed on the bottom. With continued use the ground inside the trap will become fouled with urine and trapping success will fall off.

[1] Submitted for publication December, 1955. Part of the funds for this work were made available through Federal Aid in Wildlife Restoration Act, Project California W-41-R, "Big Game Studies."

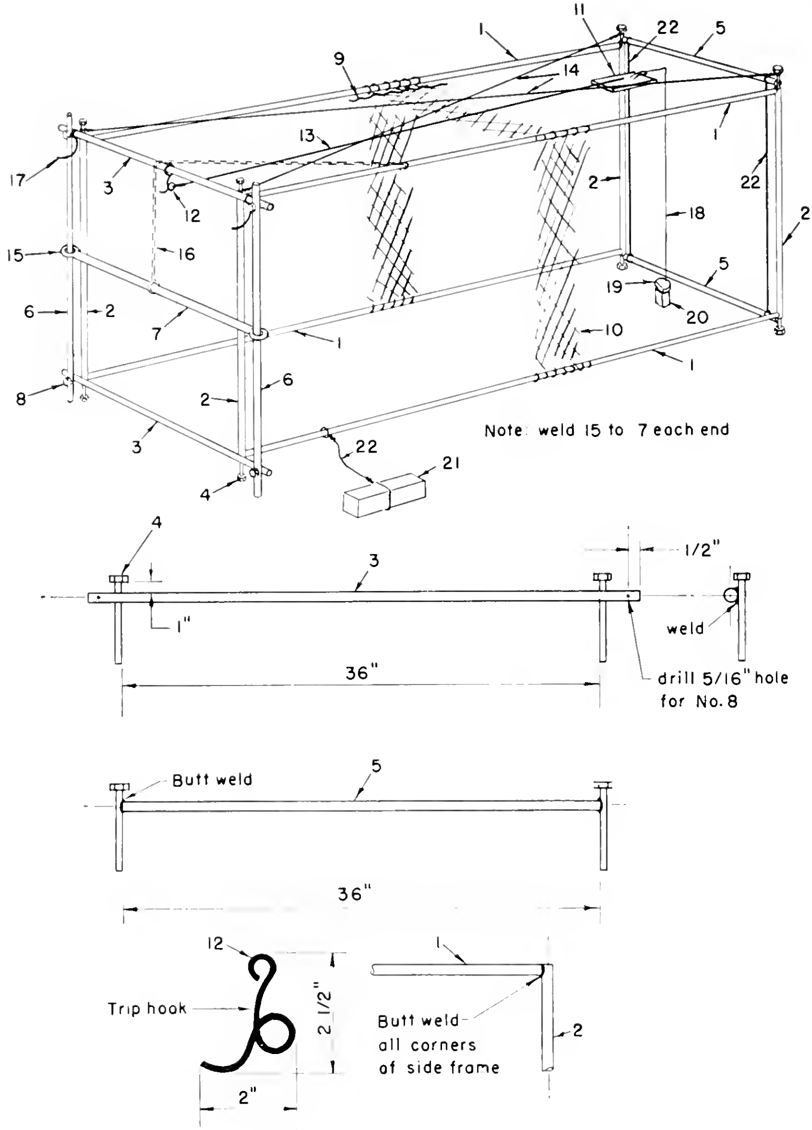

FIGURE 1. Diagram showing construction details of the single-gate deer trap. *Drawing by Cliffa Carson.*

TABLE 1

List of Materials for Clover Single-gate Deer Trap

Figure number	Material item	Pieces required
1	Black pipe, ½ x 66 inches	4
2	Black pipe, ¾ x 12 inches	4
3	Black pipe, ¾ x 43 inches	2
4	Bolt or solid rod, ¾ x 5 inches	8
5	Black pipe, ½ x 36 inches	2
6	Black pipe, ½ x 46 inches	2
7	Black pipe, 1¼ x 10 inches (cut to fit)	1
8	Machine bolts with lock washers and nuts, 5/16 x 2½ inches	4
9	Manila rope, ¼ inch, 100 feet	1
10	Webbing, 96 thread, 4½ x 5 inches stretched mesh, 4 x 17½ feet	1
11	Rat trap	1
12	Release hook, 1/8-inch welding rod	1
13	Chalk line, 6 feet	1
14	Galvanized wire, 14 gauge, 14 feet	1
15	Iron rod, 3/8-inch, formed into an oval 2½ x 3 inches inside diameter	2
16	Pull rope, ¼ inch manila, for support of runner bar	1
17	Galvanized wire, 14 gauge, 3 feet for catch-net hook	2
18	Thread, fine black nylon, small spool	1
19	Salt, piece from white stock block	1
20	Wood block, 2 x 4 x 3 inches for trip	1
21	Wood block, 1 x 3 x 5 inches for deadman	2
22	Galvanized wire, 14 gauge, 4½ feet, plus extra for attaching deadman	2

The trap should be moved occasionally at least six feet to a new location.

Trapping sites vary with local conditions. In general, moonlight necessitates the setting of traps under the cover of trees or large brush. Dark nights bring better results in the open. Any site with an abundance of fresh deer sign should be productive so long as the deer have not just migrated through the area.

Pre-baiting is important, to allow deer to become adjusted to the traps and the baits employed. During this period the traps should be wired open so that the deer have easy access and exit. Baiting for a distance of about 100 yards from each side of the trap is desirable. When trapping a migratory herd, it is advisable to place salt blocks in the prospective trapping area prior to the arrival of the deer on the range.

REFERENCE

Clover, Melvin R.
1954. A portable deer trap and catch-net. Calif. Fish and Game, vol. 40, no. 4, p. 367-373.

AN EVALUATION OF STREAM IMPROVEMENT DEVICES CONSTRUCTED EIGHTEEN YEARS AGO[1]

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INTRODUCTION

In the early 1930's, there was a sudden surge of stream improvement programs which, in the eyes of many, was destined to become the principal means of restoring depleted trout populations. With the Civilian Conservation Corps providing most of the labor, stream improvement devices were installed throughout the United States. Not as much work of this kind was performed in California as in some other states, although in several areas a considerable number of small dams, deflectors, and other devices were built. These received some initial publicity and then, for all practical purposes, were forgotten. Meanwhile, demands for the installation of stream improvement devices continued, even though little or nothing was known about the value of those previously installed.

In 1953, Federal Aid to Fish Restoration funds provided an opportunity for an evaluation of some of these improvement devices constructed 18 years before. This report is based on observations made by the writer in July, 1953, and on checks made by the United States Forest Service in 1936 and 1937. It describes the history and success of the devices and gives suggestions for future work of this kind.

HISTORY

In the fall of 1935, John D. Cassel, United States Forest Service biologist, assisted by 20 Civilian Conservation Corps men, constructed 41 stream improvement devices on the East Fork of the Kaweah River, in the Sequoia National Forest, Tulare County, California. The stream section involved lies at an elevation of about 8,000 feet in a long, flat meadow area above the town of Mineral King. The work was done on an experimental basis to determine the types of dams most suitable for creating pools.

Data for the years 1935 through 1937 were taken from reports by John D. Cassel (1935) and Paul S. Bartholomew (1936, 1937). Their reports made it possible to evaluate the success of the improvements at that time. Unfortunately, the original descriptions, drawings, and photographs of the structures are no longer available. For this reason it was possible only to infer why many of the improvements failed.

[1] Submitted for publication March, 1954. This work was performed as part of Dingell-Johnson Project California F-3-R, "Experimental Backcountry Fish Management", supported by Federal Aid to Fish Restoration funds.

basing these inferences upon observed weaknesses in the remaining structures.

At the time of the original Forest Service survey of the area, the river flow was about four to five cubic feet per second. Cassel (1935) found 44 pools in the one and one-quarter mile section where the improvement work was to be carried out. He defined a pool in this stream as "... any place where the three measurements taken at least two feet apart reveal minimum depths of 12 inches or over". Despite the

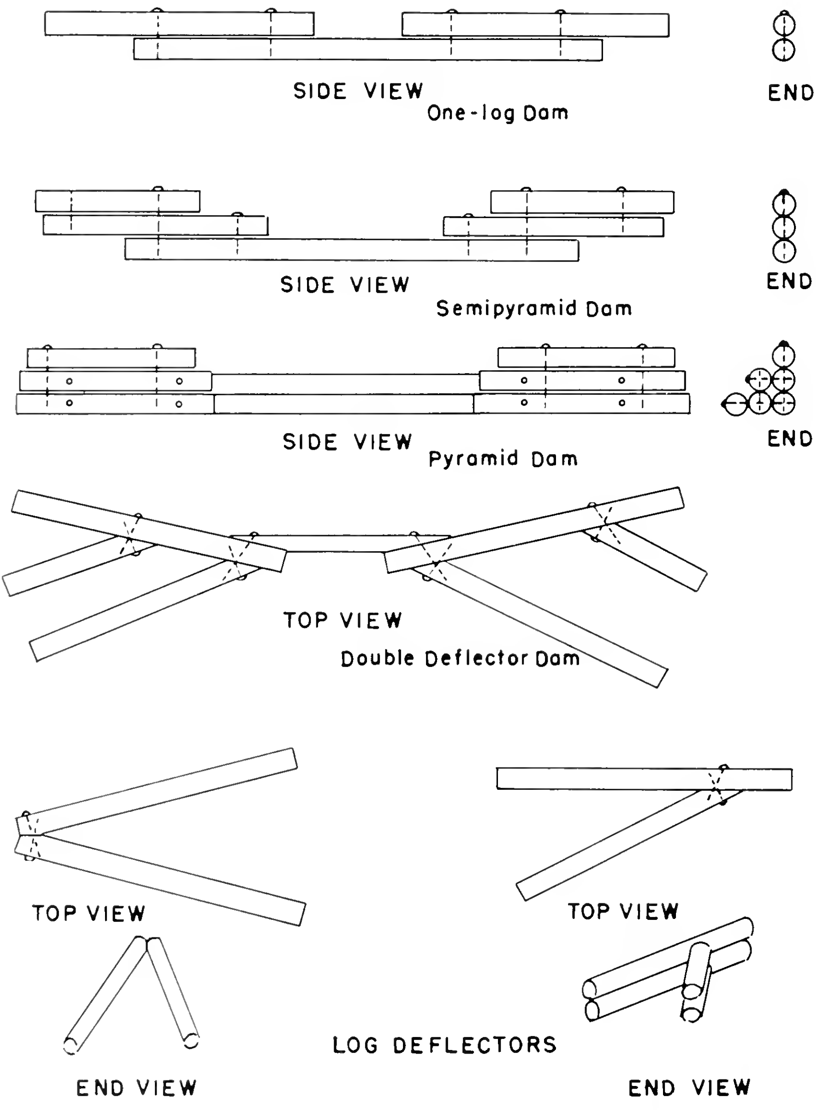

FIGURE 1. Types of log stream improvement structures employed.

large number of natural pools, he had instructions to install the check dams and, accordingly, 11 loose-rock dams (no masonry used), 15 log dams, 2 rock and log dams, 5 log deflectors, 2 earth dams, 1 wire crib dam, 1 masonry dam, 1 board dam, 1 double deflector, 1 underpass deflector, and 1 rock deflector were constructed under his supervision. The types of devices utilizing logs are shown in Figure 1.

Following the completion of the dams, Cassel observed, ". . . I have rated all 5 log deflectors as good, 10 of the dams as good, 17 structures as average, and 9 as poor. . . . . . It may be some of the structures will do more harm than good but only future surveys can reveal how and why they are harmful."

On October 26, 1936, and again on September 17, 1937, Mr. Bartholomew visited the improvement area to determine the condition of the devices and to make any needed repairs. Measurements of pool depths above and below the structures were made, and a discussion of maintenance needs and general success of the improvements was included in his reports to the United State Forest Service for the two years. Bartholomew and his crew spent about six days repairing the structures in 1936. In his 1937 report he stated, "The amount of maintenance work needed, due to the effects of high water, was approximately double the work done in October, 1936."

The number and types of devices functioning successfully during the check periods are shown in Table 1. The table reveals that the earth dams did not last even one year. Several of the rock dams were damaged severely during the winters of 1935 and 1936, but repairs were made which restored them to use. No repairs of any kind were made between 1938 and 1953.

TABLE 1

Summary of the Success of Improvement Devices

Type of structure	Number present and operating				Total present 1953†
	1935	1936	1937	1953*	
Rock dam	11	10	9	0	1
Crib dam	1	1	1	0	0
Log dam	15	15	15	6	9
Earth dam	2	0	0	0	0
Masonry dam	1	1	1	0	1
Board dam	1	1	1	0	1
Rock and log dam	2	2	2	0	0
Log deflector	5	5	5	2	5
Rock deflector	1	1	1	0	0
Double deflector	1	1	1	1	1
Underpass deflector	1	1	1	1	1
Totals	41	38	37	10	19

* Includes only those which are operating in their original locations.
† Includes nonfunctional structures also.

HISTORY OF TYPICAL STRUCTURES

Precipitation in the Sierra Nevada at the elevation of these structures occurs mainly in the form of snow. Peak flows result from occasional fall and summer thunderstorms and abnormal warm rains

which melt the snow. Water engineers estimate that the flow in the East Fork of the Kaweah River at Mineral King reached at least 900 cubic feet per second in November, 1950. Peak flows of 2,500 c.f.s. or more probably occurred at other times during the period covered by this report.

Masonry Dams

Only one masonry dam was constructed in the section. It contained a center pass box with wings to the banks on either side.

In October, 1936, this dam was undercut for 13 feet, and the foundation masonry had cracked. Repairs were made but further damage was anticipated. By 1937, undercutting was so complete that the entire middle section had collapsed. Bartholomew (1937) stated, "While the dam is an eyesore, the pool below it is good, and may be expected to improve, since the materials at the bottom are movable. The dam will act as an underpass deflector."

As shown in Figure 2, the dam has now completely collapsed, wall sections are gone, and the pass box lies lodged upside down in midstream. The main flow drops down the left side over a few remnants of the concrete wall and into a pool 15 feet long by 38 inches deep. Willows line the shore, providing good shelter for numbers of 4- to 6-inch trout. Despite the fact that this is one of the best pools throughout the improvement area, the dam itself may be considered a failure in view of its condition, maintenance needs, and general durability. It was evident after the first year of operation that the dam would collapse without constant maintenance. For this reason, little can be said in favor of this type of structure for use in areas where movable bottom materials must be utilized as a base to support masonry.

FIGURE 2. All that now remains of the rock masonry dam (structure 4) in 1953 is the pass box and a few pieces of submerged concrete. *Photograph by the author.*

Loose-rock Dams

It was apparent early in 1936 that dams of this type would require constant maintenance and repair. Some 27 crew hours were spent replacing rocks, adding seal materials, and rebuilding banks for these rock dams during 1936 and 1937. Two dams were completely washed out by 1937. Another was badly damaged and, after repairing it in 1937, Bartholomew reported that it would not survive a flood. Eroding banks and loss of seal materials with resultant undercutting were the main difficulties encountered. In most instances, damage incurred in the first two years would have resulted in a complete loss if repairs had not been made.

Figure 3 shows a rock dam in poor condition. Rock of this size will not withstand the peak runoffs that occur in the canyon. Where large rock is scarce, as in this area, construction of rock dams definitely should be discouraged. This type of dam is not only expensive to construct but requires costly annual maintenance.

FIGURE 3. In 1937 all that was left of structure 9 were a few medium-sized boulders. This is a good illustration of how inadequate the small rock available in the vicinity is for building loose-rock dams. *Photograph by U. S. Forest Service, 1937.*

All of the rock structures (arched, straight, and deflector types) had washed out by 1953. In several cases, key rocks still remain in position (Figure 4), but for the most part no remnants remain at the original sites.

Earth Dams

Two were built in order to test their durability. Both were washed out the first year and never rebuilt.

FIGURE 4. Only the key rocks of structure 30, an arched loose-rock dam, remain in position in 1953. This dam would have been effective if larger boulders had been available. *Photograph by the author.*

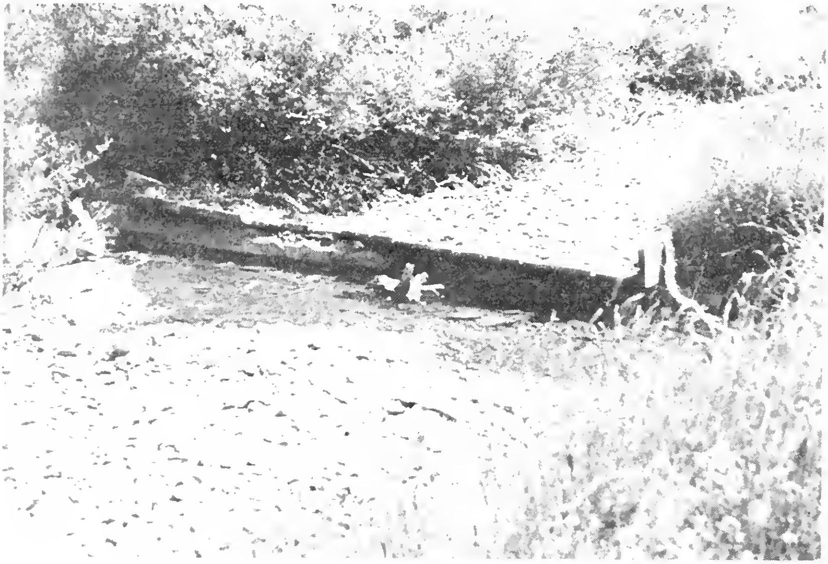

FIGURE 5. A board dam, structure 13, as it appeared in August, 1953. This channel is now dry. *Photograph by the author.*

Board Dams

The only board dam constructed in the area, although well built, was inoperative most of the time (Figure 5). Four and one-half crew hours were required to fill both ends in 1936 in order to prevent the dam from being left dry by endcutting. By 1937, 10 feet of one bank had washed out, requiring additional repairs. Further trouble was anticipated with the end fills.

TABLE 2

Maximum Depth of Pools Formed by Stream Improvement Devices *

Number and type of structure	Maximum depth of pool formed above the structure (inches)				Maximum depth of pool formed below the structure (inches)			
	1935	1936	1937	1953	1935	1936	1937	1953
1. Rock dam	20	17	30		15	25	27	20
2. One-log dam	25	20	33	WO	7	27	22	WO
3. Semipyramid	23	20	23	WO	8	27	28	WO
4. Masonry dam	32	21	22	20	8	31	33	38
5. Wire crib dam	32	22	27	WO	9	31	41	WO
6. Rock dam	16	18	15	WO	6	17	19	WO
7. Rock dam	27	18	WO	WO	9	21	WO	WO
8. Rock deflector	IN	IN	IN	WO	NM	NM	NM	WO
9. Rock dam	27	16	19	WO	15	22	29	WO
10. Rock dam	25	WO	WO	WO	14	24	24	WO
11. One-log dam	28	18	23	WO	18	35	10	WO
12. Semipyramid	34	34	31	FI	21	35	37	34
13. Board dam	35	32	36	Dry	17	42	41	Dry
14. One-log dam	38	38	40	Dry	20	27	30	Dry
15. Log deflector	21	NM	SP	Dry	12	NM	19	Dry
16. One-log dam	31	29	30	FI	17	22	26	26
17. Log deflector	23	NM	SP	SP	10	15	18	22
18. Log deflector	11	NM	NM	NF	7	NM	NM	NF†
19. Log deflector	9	NM	NM	NF	NM	NM	NM	NF†
20. Log pyramid	39	28	20	SP	24	29	34	34
21. Log pyramid	32	25	FI	WO	7	39	24	WO
22. One-log dam	17	15	15	NF	8	18	23	NF
23. Rock dam	18	15	15	WO	7	18	17	WO
24. None								
25. Earth dam	NM	WO			NM	WO		
26. Earth dam	NM	WO			NM	WO		
27. Rock dam	NM	WO			NM	WO		
28. Rock dam	21	13	18	WO	8	15	15	WO
29. Log pyramid	35	25	25	NF	18	31	29	NF
30. Rock dam	25	21	28	WO	7	21	25	WO
31. One-log dam	28	23	26	WO	18	21	25	WO
32. One-log dam	24	21	17	16	18	28	31	25
33. Underpass	13	NM	31		11	NM	32	13
34. One-log dam	33	37	31	WO	8	21	23	WO
35. Log deflector	31	NM	27	23	11	NM	NM	20
36. Double deflector	30	30	23	FI	15	28	31	32
37. One-log dam	29	33	35	FI	16	31	39	23
38. One-log dam	19	17	18	FI	10	26	26	23
39. Rock dam	23	22	23	WO	9	20	18	WO
40. Rock dam	20	24	21	WO	7	18	19	WO
41. Rock-log dam	NM	NM	29	WO	NM	NM	29	WO
42. Rock-log dam	NM	NM	32	WO	NM	NM	26	WO

WO = washed out.
NF = nonfunctional.
FI = filled in.
IN = intact.
NM = No measurement data available.
SP = Same pool as listed under "Maximum depth of pool formed below the structure (inches)."
* Data for 1935, 1936, and 1937 were taken from reports by Cassel (1935) and Bartholomew (1936 and 1937).
† May function during high water.

Flood waters have since created a new channel around the structure, leaving the dam on a dry stream bed. However, even if the flow returns to this channel, it would go around the ends of the dam where fill materials have washed out.

Log Dams

Among the log dams remaining today, the following are typical examples of their relative success. The structures are numbered according to the numerical listing in Table 2, which presents data on the depth of pools formed by the dams and deflectors.

1. *Structure 14.* One-log dam with 2-foot port (Figure 6). Partially undercut in 1936; repairs were made in two hours. In 1937 a hole under the left side required additional repairs. The channel is now dry but the effectiveness of the dam was lost when the bank washed away.

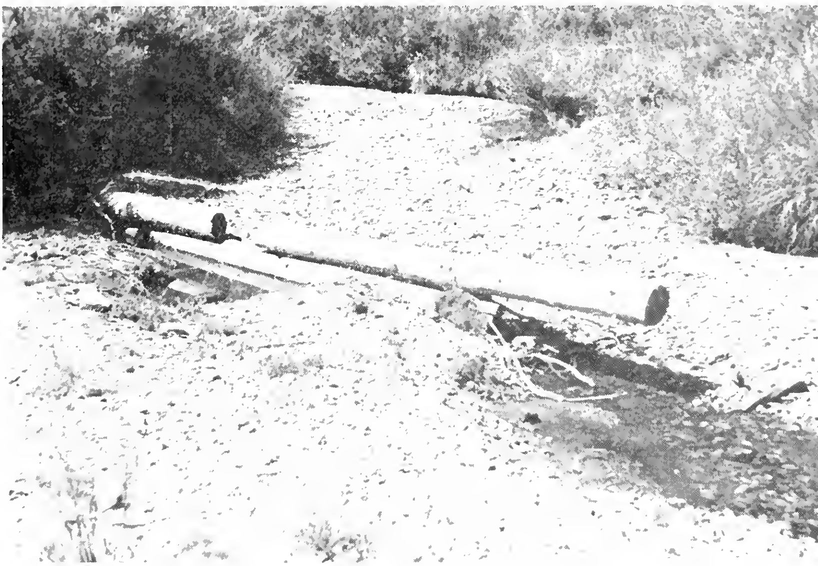

FIGURE 6. Structure 14 in 1953; a log dam, showing the results of bank erosion. This is typical one-log dam construction. *Photograph by the author.*

2. *Structure 32.* One-log dam with 6-foot port (Figure 7). Minor repairs were made in 1936 and 1937, although the dam was intact and operating very well. Good pools with good cover above and below the dam provide excellent trout habitat. This dam has proven successful, durable, and effective in creating trout pools.
3. *Structure 33.* Log underpass. Intact in 1936 but tended to catch debris. By 1937 the structure was almost filled in with gravel and repair crews converted it into a dam by adding sealing materials. Intact in 1953 but reverted to underpass type of structure. The stream seems to benefit little from this type of structure.

FIGURE 7. Taking depth measurements below structure 32, a log dam, still operating in August, 1953 *Photograph by the author.*

FIGURE 8. Structure 37, a log dam, on the downstream side in August, 1953 Another log dam that is still effective is visible in the background. *Photograph by the author*

I. *Structure 37.* One-log dam with 15-foot port (Figure 8). Relatively free of damage during 1936 and 1937; this dam is now badly undercut on one end. The pool below is 18 feet long and

23 inches deep on the undercut side. Even though most of the flow goes under the dam, the structure does maintain a good pool. Although undercut, this dam is solidly attached to both banks, well anchored by willows, and shows no evidence of deterioration.

5. *Structure 38.* One-log dam with 12-foot port. Holes under the dam in both 1936 and 1937 were repaired in a total of ten and one-half hours. Gravel filling in the pool above may be largely responsible for the fact that the dam has remained intact and operating. A good pool below is the result of water falling 10 inches from the dam crest. This dam is in no danger of washing out because a dense mat of willow roots winds through and around the ends of it. The willows are most effective anchors, as well as sources of food and cover for fish in the stream below.

Log Deflectors

Five devices of this type were built in 1935, and five were present in 1953, although not all were operating. Structures 17, 18, and 19 are shown in Figure 9. They are still in excellent condition. Some repairs were made during 1936 and 1937, when trampling by cattle threatened to break down the banks. However, little change has occurred here since 1936 insofar as damage to the structures is concerned. Two of the devices are operative only in high water. All are on a bend in the stream and successfully retard bank erosion during peak winter flows.

FIGURE 9. Three log deflectors in 1953. Structure 17 is in the foreground and has largely diverted the stream to the left. Structure 18 in the middle distance and 19 in the background have been undercut and have lost some of their effectiveness. *Photograph by the author.*

In Figure 10 another deflector can be seen performing the task of sod and bank protection. A threatened washout in 1936 was prevented by filling the structure with rock, digging a cutoff channel around the

FIGURE 10. Structure 35 in August, 1953; a log deflector filled with rock. The rock protector is visible in the foreground. The success of this deflector is the result of careful anchoring. *Photograph by the author.*

FIGURE 11. Structure 36, a double-log deflector on the downstream side. The V-type of construction restricts the flow to the center. A cross log in the V gives eight inches of fall and prevents undercutting in the spill. *Photograph by W. A. Dill, August, 1953.*

open end, and installing a rock protector on the upstream bank. This device is in good condition and still operating.

Double Deflector Dam

Labelled one of the best structures of the entire group in 1935, practically no damage has been done to this dam since that time. It is a solid, well-braced device of heavy construction and well suited for use in steep drainages. Figure 11 shows how slanting logs, tied together across the 3-foot spill, concentrate the flow through the center of the pool. A slightly wider spill would have been desirable to prevent formation of sand bars extending to shore on both sides of the pool. There is no longer a pool above, but the pool below is 25 feet long and has decreased in depth only about 2 inches since 1937.

DISCUSSION

Among the 67 pools developed or expected to develop as a result of the 41 dams and deflectors built in the East Fork of the Kaweah River in 1935, only 15 pools remained in 1953. These included pools above and below the intact structures, as well as those formed by the remains of damaged structures. Nine of these pools lie below the structures, three above, and three are continuous above and below in the case of undercut dams or deflectors. Only one of the dams has a pool above; all others have filled in. It may be that by filling in above, the life of a dam is appreciably prolonged.

The best pools are usually formed below artificial improvements, due to the force of falling water constantly digging out bottom materials and preventing sedimentation. Upstream pools, on the other hand, lacking fall and having barriers at the downstream end, tend to fill with sediment. In the event of floods, variations will occur.

In spite of the maintenance required in 1936 and 1937 to prevent their loss, all of the loose-rock dams have now been washed away or are damaged beyond repair. Since there was a scarcity of large rock in the vicinity, these dams were built chiefly of rock transported from other areas. With a limited supply to choose from, it was only natural that the rocks would fit loosely. Consequently, these dams did not prove very effective for any length of time and went to pieces rapidly. Even where adequate building materials are present, constant maintenance may be expected. This is especially true in mountainous areas, where the rock dams must endure periods of high water.

The log dams present a different picture. There is no doubt that all of the log dams were well built. White fir logs, well secured with heavy iron drift pins, were used. These logs showed no sign of rot or deterioration in 1953. In no case were any of the dams shattered or pried apart. In fact, four dams that were washed out still lie intact along the stream. The fault lies not with the dams themselves but with soft banks and inadequate anchoring.

The eight log dams which were lost were either washed out completely or were undercut or endcut. Low banks of loam with low rock content are especially susceptible to erosion. Similarly, the small rubble and gravel of the stream bed shifts with fluctuating flows and changing currents. Figure 6 illustrates a good example of endcutting which

resulted in a shift of the entire stream around the end of the dam. Undercutting may be seen in numerous locations.

Two conditions were characteristic of the dams still operating in 1953 in the improvement area. The more obvious was the presence of good stands of willow and other rooted vegetation growing at their ends. Since all of them exhibited this condition, it might well be one of the most important factors involved in permanently anchoring these and other artificial devices into the bank. For example, the anchoring area in structure 38 was examined rather extensively. Willow roots were found to extend in all directions to form a thick mat completely entwining the extremities of the logs. Not only does such vegetation bind soil and rock together, but it also provides much needed cover for fish and wildlife. There is a shortage of cover in many pools throughout the section. Wherever willows have grown up along the margin, cover is generally good, and the bulk of the fish population is found in these places.

The second condition, typical of the dams and also of the log deflectors, lies in the anchoring methods used. Considerably more rock was employed in anchoring certain of the dam structures. These were the more successful ones. All of the log deflectors were heavily packed with rock, and all of them remained in 1953. In Figure 12 one end of a log dam is shown with only a few rocks as anchors. Experience has shown that this is insufficient anchoring material to withstand even a high runoff, much less a flood.

FIGURE 12. Anchoring methods such as this were not able to hold a dam in place. *Photograph by U. S. Forest Service, 1937.*

Wherever large rock fills have been used along with deep abutments in the banks, surprisingly little damage has occurred. Figure 9 shows examples of structures built well into the bank. Five or six feet is con-

sidered satisfactory. Three to four feet appears to have been the rule in 1935. One cannot foretell how a dam will survive flooding. All available evidence, however, points to a lack of sound anchoring as the primary cause of failure.

CONCLUSIONS

1. Damage or loss of loose-rock dams is inevitable in regions such as this, where flooding occurs periodically and where adequate building materials are scarce.
2. Every attempt should be made to construct improvements where natural bracing, such as trees or large boulders, is present.
3. Log dams should be built 5 to 6 feet into the banks and anchored with large rocks. Vegetation is a valuable anchoring tool, as well as a source of food and cover for trout.
4. Where they can be firmly anchored, log dams are suitable for small streams. They are of little value where floods carry large boulders down on them.
5. Log dams are superior and generally more durable than rock dams on streams of slight gradient.
6. Masonry and rock crib dams are of doubtful value when constructed on a gravel bed.
7. Pools formed below the structures are more permanent than pools above.
8. Maintenance work will be necessary wherever stream improvements of these types are built.

SUMMARY

An evaluation of stream improvement devices on the East Fork of the Kaweah River was made in 1953. Ten out of a total of 41 improvement structures installed by the United States Forest Service in 1935 remained in operation after 18 years of service. Only log structures were intact, while rock, masonry, earth, and crib dams had washed out. Nine additional structures were still present in 1953, but were either nonfunctioning or had been damaged to the extent that they were of minor value.

Fifteen pools have resulted from the original 41 improvements. This includes nine pools below the structures, three pools above, and three pools continuous above and below. Most pools formed above have tended to fill in, while those below remain more or less constant in depth, depending on stream volume and velocity.

From all indications, the failures resulted from the endcutting and undercutting action of water on the loose bottom and bank materials. Rock, earth, and masonry dams are especially susceptible to flood damage. Log structures, on the other hand, hold very well providing they are adequately anchored. A lack of large rock in the area for suitable anchoring material seems responsible for the loss of many structures.

Willows and other rooted vegetation were present in most cases at the extremities of the remaining operating structures. In those cases where vegetation was not present, the improvements were either heavily anchored with large rock, built 5 to 6 feet into the bank, or had a combination of these two features.

LITERATURE CITED

Bartholomew, Paul S.

1936. Report on stream improvement structures at Mineral King. U. S. Forest Service report, 7 p. (Typewritten)

1937. Report on maintenance work on the Mineral King dams. (Extracts). U. S. Forest Service report, 7 p. (Typewritten)

Cassel, J. D.

1935. Report on stream improvement in the East Branch of the Kaweah River in the Sequoia National Forest. U. S. Forest Service report, 7 p. (Typewritten)

THE YELLOW PERCH, *PERCA FLAVESCENS* (MITCHILL), IN THE KLAMATH RIVER[1]

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INTRODUCTION

The primary purpose of this study, undertaken in 1951, was to determine the relationship between yellow perch (*Perca flavescens*) and young salmonids in the Klamath River.

Yellow perch are indigenous to the eastern part of the United States and Canada. Their native range includes the Hudson Bay drainage, south to Ohio, and Nova Scotia to the Dakotas. Through fish-cultural activities their distribution outside this range has been widespread.

Curtis (1949) reports that yellow perch were first introduced into California in 1891. Several subsequent importations were made. He further notes that by 1918 they were widely distributed in the Sacramento-San Joaquin River drainage, although not numerous, and then appear to have vanished from this area. However, specimens are still occasionally taken in the drainage, with an apparent concentration in Snodgrass Slough, Sacramento County.

Yellow perch were first collected in the Klamath River in California on May 4, 1946, when anglers brought four specimens from Copco Lake to the Fall Creek State Fish Hatchery for identification (Figure 1). Copco Lake is a storage reservoir of the California Oregon Power Company on the Klamath River near the California-Oregon state line. Although but little is known of their spread downstream, a 6-inch perch was collected just above the U. S. Highway 101 bridge at the town of Klamath, near the mouth of the river, on June 11, 1951. Yellow perch now are abundant in Copco Lake and are fairly common in the numerous dredge-pond backwaters along the upper Klamath River. How they entered the Klamath River is not definitely known, but probably they either descended the river from Oregon or were "unofficially" planted in Copco Lake.

Yellow perch are also present in Lost River near Tulelake, Siskiyou County, and in the various irrigation canals just east of Tulelake in Modoc County.

METHODS

The majority of the perch were collected with riffle-type fyke nets of one-half-inch stretched mesh, which were usually set overnight in riffles just below the quieter stretches of the river, or in connecting channels between dredge ponds and the river. Others were taken by gill net, chemical treatment of backwater dredge ponds, hook and line,

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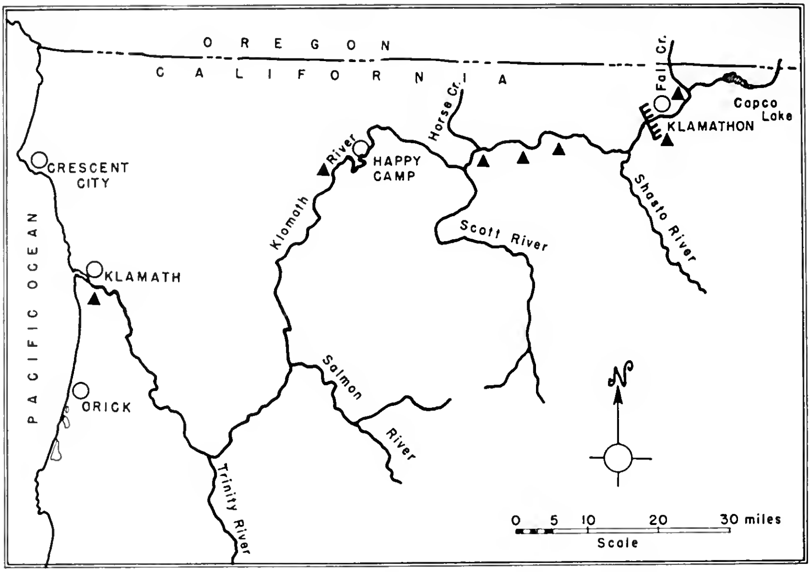

FIGURE 1. Map of the Klamath River in California. Black triangles indicate collecting localities for yellow perch.

and by means of a mechanical fish trap installed in the Klamath River at the Klamathon Egg Collecting Station, 16.5 miles below Copco Dam.

Fyke and gill netting were not satisfactory methods of collecting perch for stomach examinations. After a prolonged period in the nets, many of the fish had either digested or regurgitated their food.

The following fishes are associated with the yellow perch in the Klamath River:

Pacific lamprey, *Entosphenus tridentatus*
King salmon, *Oncorhynchus tshawytscha*
Silver salmon, *Oncorhynchus kisutch*
Steelhead rainbow trout, *Salmo gairdneri gairdneri*
Klamath small-scaled sucker, *Catostomus rimiculus*
Klamath tui chub, *Siphateles bicolor bicolor*
Klamath speckled dace, *Rhinichthys nubilus klamathensis*
Brown bullhead, *Ameiurus nebulosus*
Largemouth bass, *Micropterus salmoides*
Green sunfish, *Lepomis cyanellus*
Pumpkinseed, *Lepomis gibbosus*
Sculpin, *Cottus* sp.

AGE AND GROWTH

Scales from 140 perch were mounted and "read". Measurements were made from the focus to the extreme anterior edge of the scale along an interradial space, using an Ames dial gauge attached to a compound microscope. The growth (Table 1) was calculated on the assumption that at the time of annulus formation a direct proportion existed between scale length and fork length. Annulus formation of

TABLE 1

Calculated Growth Rates of Klamath River Yellow Perch in Each Age Group

Age class	Number examined	Fork length in inches at end of year of life				
		I	II	III	IV	V
I	39	3.50				
II	61	3.31	5.67			
III	33	3.34	5.54	7.26		
IV	4	3.54	5.92	7.49	8.18	
V	3	3.31	5.90	7.40	8.83	10.10
Total	140					
Average calculated fork length		3.38	5.64	7.30	8.63	10.10
Average calculated increment		3.38	2.26	1.66	1.33	1.47
Range		2.53-4.47	4.31-6.70	6.16-7.82	8.10-9.30	9.60-10.30
Average calculated standard length		3.00	5.01	6.46	7.66	8.97
Average calculated standard length (mm.)		76	127	164	195	228
Average calculated total length		3.55	5.92	7.67	9.06	10.61

perch collected from the Klamath River appears to be completed sometime during the period March through May. The season's growth is completed during October and November.

The growth of yellow perch young-of-the-year may be traced in Figure 2.

A comparison of the average calculated total lengths at each annulus with data compiled by Carlander (1950, 1953) indicates that the perch

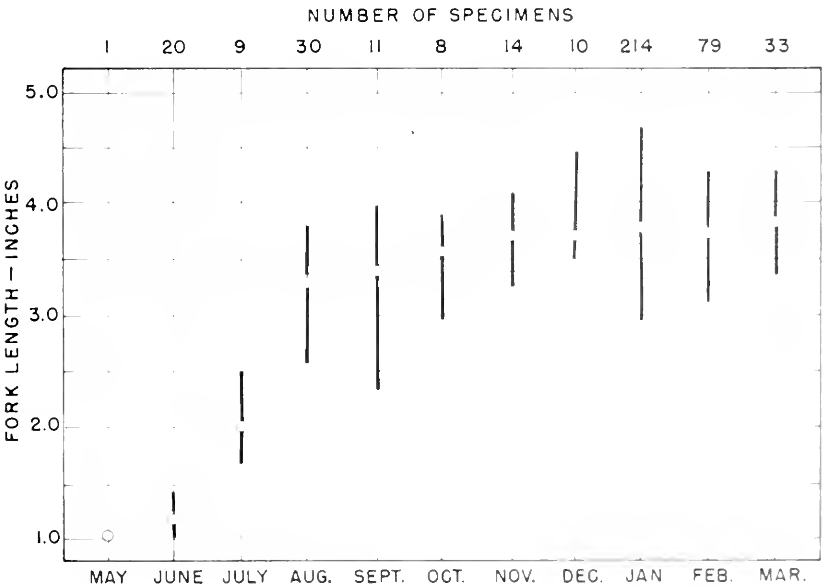

FIGURE 2. Range and mean length of yellow perch young-of-the-year collected from the Klamath River, May, 1951, through March, 1952.

collected from the Klamath River displayed a growth rate comparable to that in other waters (Table 2).

TABLE 2

Comparison of the Calculated Total Lengths at Each Annulus of Klamath River Yellow Perch With Those From Various Waters

Location	Number of fish	Total length in inches at end of year of life								Authority*
		I	II	III	IV	V	VI	VII	VIII	
New Hampshire, Shawtown Lake	--	2.8	3.9	4.6	5.1	6.0	6.7			Stroud (1942)
Montana ponds	32	2.6	5.3	6.6	7.0					Brown and Thorenson (1951)
Virginia, Claytor Lake	59	3.1	5.5	8.5	9.9					Roseberry (1951)
Lake Erie	2,644	3.7	6.7	8.5	9.5	10.4	11.0			Jobes (1952)
Lake Michigan	--	2.8	4.5	6.0	7.1	8.5	9.7			Van Oosten (1948)
Minnesota	--	2.1	4.5	6.3	7.7	9.2	9.6	10.4	10.9	Smith and Moe (1944)
Iowa, Red Haw Lake	87	3.7	7.2	10.3						Lewis (1950)
Iowa, East Lake	88	3.4	5.7	7.1	7.6	8.2	9.3			Lewis (1950)
Connecticut	224	3.7	6.0	7.7	9.0	9.9	10.6	11.2	11.6	Thompson (1942)
California, Klamath River	140	3.5	5.9	7.7	9.0	10.6				

* Taken from Carlander (1953).

LENGTH-WEIGHT RELATIONSHIP AND CONDITION

A total of 848 yellow perch was measured during the course of this study (Table 3). Fork length measurements and weights were taken from 276 fish (Table 4). Thirty-three of the specimens, ranging from

TABLE 3

Fork Lengths of 848 Yellow Perch From the Klamath River March, 1951, Through March, 1952

Midpoint length in inches	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1.0	--	-	1	14		--	--	--	--	--	--	--	--
1.5			--	6	2	--		--	--	--	--	--	--
2.0	--		-		7	--	--	-	-	--	--	--	--
2.5		-	-	-	2	2	1	--	--	--	--	--	--
3.0	8	3			-	21	3	3	--	--	14	4	--
3.5	11	6	3	-	--	9	6	5	8	7	92	41	14
4.0	6			1	15	--	1	--	6	2	87	33	17
4.5	2	1	--	2	24	1	--	--	--	1	21	3	2
5.0	2	3	7	3	15	8	2	--	--	--	2	--	--
5.5	11	4	7	11	19	3	1	1	--	--	3	--	--
6.0	9	10	1	9	32	4	2	1	1	4	4	2	1
6.5	4	5	2	8	20	4	1	3	--	2	5	4	1
7.0	1	--	--	4	6	--	1	--	--	3	10	1	1
7.5	--	--	4	6	-	1	--	--	2	4	10	1	1
8.0	--	--	6	--	1	-	--	--	--	--	14	--	--
8.5	--	--	-	--	--	--	2	--	--	1	1	--	--
9.0	--	--	--	--	--	--	--	--	--	--	2	--	--
9.5	--	--	1	-	--	--	--	--	--	--	--	--	--
10.0	--	--	--	--	--	--	--	--	--	--	--	--	--
10.5	2	--	--	--	--	--	--	--	--	--	--	--	--
Totals	56	35	32	64	143	53	20	13	17	24	265	89	37

TABLE 4

Length-weight Relationship and Coefficient of Condition of Klamath River Yellow Perch

Number of fish	Fork length midpoint (inches)	Fork length midpoint (mm.)	Calculated weights (ounces)	Calculated weights (grams)	Total length* (inches)	Standard length* (mm.)	Coefficient of condition C (English)	Coefficient of condition K (metric)
2	1.8	45	0.04	1.1	1.9	40	36	1.66
1	2.2	55	0.06	2.0	2.3	49	36	1.66
1	2.6	65	0.1	3.2	2.7	58	36	1.65
1	3.0	75	0.2	5.0	3.1	67	36	1.66
6	3.4	85	0.3	7.3	3.5	75	38	1.73
22	3.7	95	0.4	10.2	3.9	84	38	1.72
31	4.1	105	0.5	13.9	4.3	93	38	1.72
37	4.5	115	0.7	18.3	4.8	102	38	1.72
19	4.9	125	0.8	23.5	5.2	111	38	1.72
14	5.3	135	1.0	29.7	5.6	120	38	1.72
14	5.7	145	1.3	36.8	6.0	129	37	1.71
25	6.1	155	1.6	45.2	6.4	138	38	1.72
18	6.5	165	1.9	54.6	6.8	146	38	1.75
17	6.9	175	2.3	63.4	7.2	155	38	1.75
17	7.3	185	2.7	77.4	7.6	164	39	1.78
22	7.7	195	3.2	90.6	8.1	173	38	1.75
15	8.1	205	3.7	105.5	8.5	182	38	1.75
8	8.5	215	4.3	121.9	8.9	191	38	1.75
2	8.9	225	4.9	139.9	9.3	200	38	1.75
2	9.3	235	5.6	159.6	9.7	209	38	1.76
2	9.7	245	6.4	181.1	10.1	218	38	1.75
Total 276								
Mean							38	1.73

* The following length-conversion factors were determined: total length equals 1.050 fork length; fork length equals 1.126 standard length; standard length equals 0.888 fork length; total length equals 1.182 standard length.

45 mm. to 95 mm. in length, were obtained from May through September, 1952. The remaining or larger fish were taken during October, November, and December, 1952. The least squares calculation (Figure 3) of the length-weight relationship was as follows:

Log W (weight in grams) = —4.9915 plus 3.0343 log L (length mm.).

The relative plumpness of the fish or coefficient of condition is shown in Table 4. Klamath River yellow perch showed very little change in condition with increasing length and weight. A comparison of their condition indexes with data complied by Carlander (1950) indicates that they are well below average. Various factors which might contribute to this situation include time of collection, size, age, and sex of the individuals. The fish weighed and measured in this study were not sexed. The majority of them were collected during late fall and early winter, when falling water temperatures may have lowered their metabolic rate and resulted in the below average condition indexes. However, according to Le Cren (1951) a related species, *Perca fluviatilis* in Lake Windermere, England, attains its highest condition in the late fall and early winter.

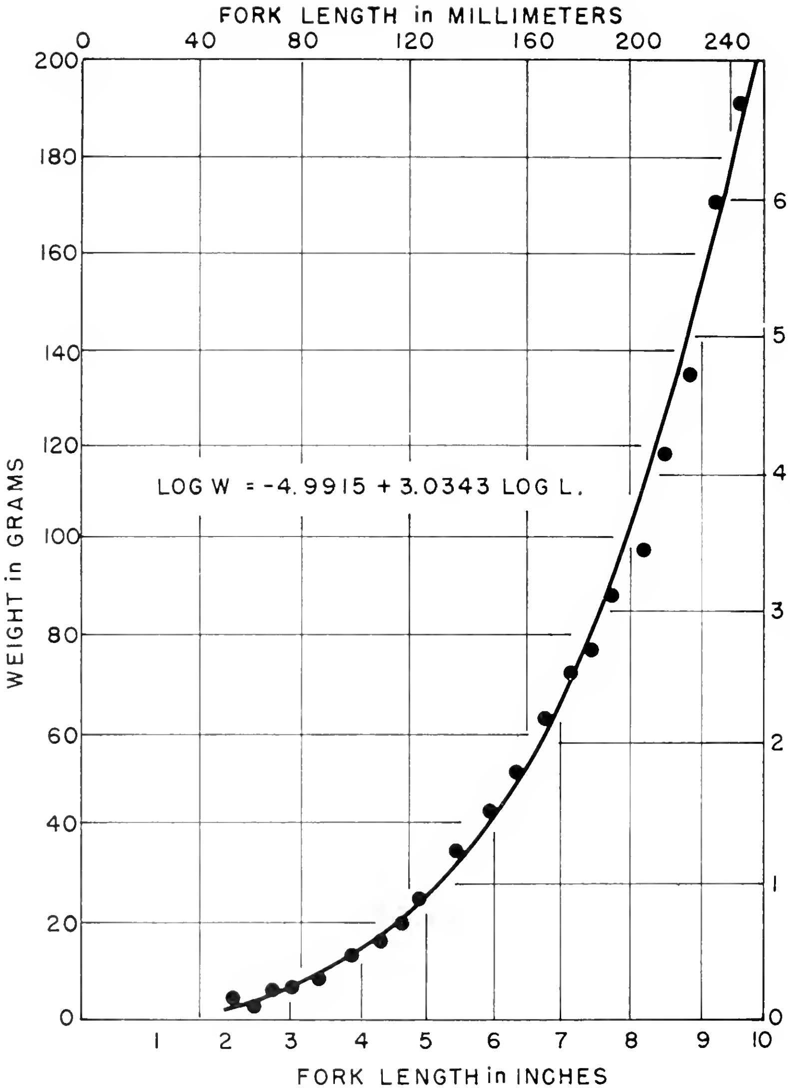

FIGURE 3. Length-weight relationship of yellow perch from the Klamath River. The smooth curve is the solution of the equation; the dots show the actual weights at various lengths.

FOOD HABITS

The stomachs of 731 perch, 474 of which were empty, were examined between March, 1951, and March, 1952. An additional 149 perch were checked for the presence of salmonids in their stomachs subsequent to this period. No salmonids were found in either sample.

During February, March, and April, 1952, a mechanical fish trap was operated in the Klamath River at Klamathon Egg Collecting Station to capture downstream migrant king salmon fingerlings. In addi-

tion to considerable numbers of young salmon and steelhead, many yellow perch were collected. Some of them were examined shortly after being trapped, but no salmonids were noted in their stomachs.

Small crustaceans, mollusks (particularly small snails), aquatic insect larvae and nymphs, and fish constituted the major food items. Very few surface and adult insects were observed. Out of the 257 perch stomachs containing food, only 34 contained fish remains. These consisted of small chubs, dace, suckers, yellow perch, and green sunfish. Fish did not appear to enter the diet of perch until about their second year. Algae, bits of aquatic vegetation, and even fragments of bark were also present.

Live trap and aquarium tests with adult perch and fingerling king salmon and steelhead indicate that perch will eat young salmonids if provided with the opportunity. Six 8-inch perch and 21 steelhead fingerlings averaging about two inches in length were placed in a floating live trap in a quiet eddy of the Klamath River near Klamathon Egg Collecting Station. Within five days all of the fingerlings had disappeared, apparently consumed by the perch. The river was very turbid during this test. In another instance 17 king salmon fingerlings were left in an aerated aquarium with a 7-inch perch. In 11 days all of the salmon had been eaten by the perch. Fifteen steelhead fingerlings were put into the aquarium with two adult perch. All were consumed within 72 hours.

SPAWNING ACTIVITY

Yellow perch have been reported to spawn in the spring at temperatures from 45 to 55 degrees F. (Curtis, 1949). Their eggs are emitted in ribbons.

No perch were actually observed spawning in the Klamath River during this study. On March 28, 1951, strings of perch eggs were recovered from a growth of tules about one-half mile below the mouth of Fall Creek by means of a small minnow seine. These ribbons of eggs averaged about one and one-fourth inches in width and were from 6 to 12 inches in length. Possibly they had been longer, but were broken because of their fragile condition. An overnight fyke net set in this vicinity the following day recovered 19 ripe perch from 7 to nearly 10 inches in length. The water temperature of the river at noon on this date was 47 degrees F. During April, 1951, fragments of egg strands, assumed to be of perch, were recovered from fyke nets set in the river. The first spent perch was collected on April 4, 1951, and the last ripe fish was caught on May 18, 1951. The morning water temperature on the latter date was 59 degrees F. Periodic water temperatures of the river during April, 1951, usually taken before noon, ranged from 44 to 56 degrees F.

PARASITISM, DISEASE, AND PREDATION

Very little evidence of parasitism and disease has been observed in perch collected from the Klamath River. A few have shown lamprey scars. Several perch caught during March, 1953, bore identical lesions just posterior to the soft part of the dorsal fin. Two of these fish were examined by Harold Wolf, parasitologist for the Department of Fish and Game. He found no myxosporidia but noted many bacteria in the

lesions. No parasitic nematodes were found in the body cavities during the course of stomach examinations, although these parasites, particularly *Contracoecum spiculigerum,* are usually common in Klamath River centrarchids and salmonids. Haderlie (1953) examined 18 yellow perch from Copeo Lake on May 21, 1949, and found no parasites.

Yellow perch have been recovered from the stomachs of fish-eating birds, especially mergansers, along the Klamath River. An adult steelhead caught in the Klamath River near Fall Creek on October 12, 1951, had a 4-inch perch in its stomach.

THE SPORT FISHERY

The sport fishery for yellow perch in the Klamath River is negligible in comparison with the fishery for salmon and steelhead. Very few anglers have been noted actually fishing for perch. Trout fishermen, while fishing the quieter stretches of stream or in the vicinity of backwater dredge ponds, occasionally catch a perch. These are usually discarded as "trash" fish. Catfish anglers, frequenting the many backwater dredge ponds along the river, catch quite a few perch and usually keep them. The majority of the fish taken by anglers are from 5 to 8 inches in length. Under present angling regulations there is no bag limit or season on yellow perch.

Copeo Lake has an abundant population of yellow perch. For such a large body of water (over 1,500 surface acres) and ease of access the number of anglers is small, but is gradually increasing. There have been unverified reports of perch up to a pound in weight being caught, but the largest fish observed was approximately 12 inches in length and less than one-half pound in weight.

Yellow perch are easily caught. Bait such as worms, salmon eggs, small crayfish, and grasshoppers are the most popular lures, but a few are caught with small spinners and flies. Bait anglers usually use a very light sinker, so that the bait gradually sinks to the bottom. Perch invariably nibble and peck at the bait before swallowing it. The usual method at Copeo Lake is to fish in a cove or where the shore line drops to deep water. If no fish are caught within a few minutes the angler moves to another similar location and tries again. Perch generally move in schools.

The eating qualities of yellow perch are very high. The body cavity is relatively small. The flesh is white, firm, flaky, and sweet, with a minimum of bones. Instead of being scaled, they can be skinned in the same manner as bullheads or catfish and sliced into fillets. Anglers have stated that the latter method removes the fishy or mossy tang characteristic of Klamath River fishes during the warm summer months.

DISCUSSION

Yellow perch appear to be well distributed in the Klamath River wherever suitable environment occurs, as in backwater dredge ponds or quiet stretches of stream. Based on gill net sets and chemical sampling of dredge ponds, perch are not numerous in comparison with other fishes. For example, chemical treatment of a small cove in a dredge pond near Horse Creek on May 24, 1951, yielded 46 brown bullheads, 159 Klamath small-scaled suckers, 152 Klamath speckled dace, 21 Kla-

math tui chubs, 169 green sunfish, 122 pumpkinseeds, 4 largemouth bass, 2 yearling steelhead rainbow trout, and 16 yellow perch.

There appears to be a marked influx of perch from Copco Lake downstream into the Klamath River during periods when water is being spilled over the crest of 126-foot high Copco Dam. During the month of January, 1951, when water was being spilled, considerable numbers of perch were recovered by trapping and fyke netting in the river at Klamathon, 16.5 miles downstream from Copco Dam. Fewer fish were collected at this locality when water was not being spilled during January. Many of the perch recovered from the trap when water was being spilled were alive and could have come from Copco Lake and survived the drop over the dam. Whether perch and other fishes can survive passage through Copco's power generating turbines, which are of the reportedly harmful Francis type, is not known and requires additional study.

The possible introduction of yellow perch into other waters should be viewed with caution. Perch will thrive in some waters suitable for trout. Under such conditions they compete with trout for food and undoubtedly prey upon their young. Some studies have indicated that the survival and growth of trout are poor in bodies of water where perch are present. Other investigations have shown that perch have become a "problem" fish because of a tendency to become stunted, particularly in smaller bodies of water or under light angling intensity.

SUMMARY

Yellow perch were first noted in the upper Klamath River drainage in California in 1946.

Measurements were taken from 848 fish ranging from 1.2 to 10.4 inches, fork length.

The stomachs of 731 perch, 474 of which were empty, were examined. A cursory check was made of an additional 149 stomachs. No young salmonids were found in them. However, live trap tests with adult perch and salmon and steelhead fingerlings showed that perch will consume young salmonids under artificial conditions.

Weights and lengths were taken from 276 fish. The least squares calculation of the length-weight relationship was: log W (weight in grams) = —4.9915 plus 3.0343 log L (length mm.).

Scales from 140 fish were "read" and ages determined. The growth rate of yellow perch from the Klamath River is comparable with that in other waters.

REFERENCES

Bardach, John E.
1951. Changes in yellow perch population of Lake Mendota, Wisconsin, between 1916 and 1948. Ecology, vol. 32, no. 4, p. 719-728.

Carlander, Kenneth D.
1950. Handbook of freshwater fishery biology. Dubuque, Wm. C. Brown Co., 281 p.
1953. First supplement to handbook of freshwater fishery biology. Dubuque, Wm. C. Brown Co., p. 277-429.

Curtis, Brian
1949. The warm-water game fishes of California. Calif. Fish and Game, vol. 35, no. 4, p. 255-273.

Dill, Wiliam A., Millard Coots, and Philip A. Douglas
1955. The status of the pumpkinseed, *Lepomis gibbosus* (Linné), in California. Calif. Fish and Game, vol. 41, no. 2, p. 157-159.

Eschmeyer, R. William
1936. Some characteristics of a population of stunted perch. Mich. Acad. Sci., Arts and Let., Pap., vol. 22, p. 613-628.
1948. The status of legal restriction in fish conservation. Internat. Assoc. Game, Fish and Cons. Comm., 38th Conv., p. 11-18.

Haderlie, Eugene Clinton
1953. Parasites of the fresh-water fishes of northern California. Univ. of Calif., Publ. in Zool., vol. 57, no. 5, p. 303-440.

Lagler, Karl F.
1952. Freshwater fishery biology. Dubuque, Wm. C. Brown Co., 360 p.

Le Cren, E. D.
1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Jour. Anim. Ecol., vol. 20, no. 2, p. 201-219.

Parsons, John W.
1950. Growth studies of the yellow perch, *Perca flavescens* (*Mitchell*), in three northwest Iowa lakes. Iowa St. Coll., Jour. Sci., vol. 25, no. 3, p. 495-500.

NOTES

A BISEXUAL STEELHEAD

Hermaphroditism in trout and salmon appears to be very rare and worthy of note, since published records are few in number.

A bisexual silver salmon (*Oncorhynchus kisutch*) was reported from the Chehalis River in Washington (Crawford, 1927), and a hermaphroditic cutthroat trout (*Salmo clarki*) was collected in Yellowstone Lake, Wyoming (Turner, 1946). A king salmon (*O. tshawytscha*) with reproductive organs showing both male and female characters was taken in 1954 near Fort Bragg, California, and is now being studied by O. H. Robertson at Stanford University. The published records known to the writer are listed in the references.

An adult sea-run steelhead rainbow trout (*Salmo g. gairdneri*) having both male and female reproductive organs was caught in the South Fork of the Eel River near the town of Garberville, Humboldt County, California, on January 7, 1955, by Mr. H. L. Kniveton of Farmington, California. The gonads were given to Warden Robert Perkins of Garberville, who gave them to the writer. Correspondence with Mr. Kniveton revealed that the steelhead weighed eight pounds and had the superficial appearance of a male fish.

The female portions of the two gonads differ considerably in size (Figure 1), one extending about two-thirds the length of the gonad, while the other is less than half the length of the gonad. Although the male and female portions of the gonads appear to be distinct, some eggs are embedded irregularly throughout the male tissue.

The eggs are much smaller than one would expect to find in a sexually mature female steelhead of the same size. The testes in a normal male steelhead of the same size would more nearly approach the size of the gonads in the fish under discussion.

REFERENCES

Brunn, A. W. von

1896. Ueber die neueren die Entwicklung des Pancreas betreffenden Arbeiten. Arch. Ver. Freunde Naturg. Mecklenburg, 49. Jahrb., 2. Abth., p. xxix-xxxi.

Couch, J.

1868. Irregularities of structure in fishes. Student and Intell. Observ., vol. 1, p. 328-336.

Crawford, D. R.

1927. Notice of hermaphroditism in silver salmon, *Oncorhynchus kisutch*. Copeia, no. 163, p. 34.

DeBeer, G. R.

1924. Note on a hermaphrodite trout. Anat. Rec. Philadelphia, vol. 27, p. 61-62.

Simpson, J. Y.

1839. Hermaphroditism. *In:* Todd's Cyclopaedia of Anatomy and Physiology, London. 1836-39, vol. 2, p. 697.

FIGURE 1. Gonads of adult bisexual steelhead caught in the South Fork of the Eel River on January 7, 1955. *Photograph by Chester A. Woodhull.*

Stewart, C.
1891. On a hermaphrodite trout (*Salmo fario*). Jour. Linn. Soc. London (*Zool.*), vol. 24, p. 69.

Turner, C. L.
1946. A case of hermaphroditism in the cut-throat trout. Chicago Acad. Sci., Nat. Hist. Miscellanea, no. 1, p. 1-2.

Weber, M.
1884. Ueber Hermaphroditismus bei Fischen. Nederl. Tijdschr. Dierk. Ver. Amsterdam, pt. 1, 1884, p. 21-43. *Ibid.*, 1885-87, p. 128-134.

—*Earl D. Gibbs, Inland Fisheries Branch, California Department of Fish and Game, July, 1955.*

UNUSUAL OCCURRENCE OF THE RING-TAILED CAT

In checking over experimental wood duck nest boxes set out by the Department's Pittman-Robertson Waterfowl Study Project, ring-tailed cats (*Bassariscus astutus*) were found occupying boxes on Butte Creek, three miles northeast of Colusa on the floor of the Sacramento Valley. The area has a typical riparian growth of dense brush and trees.

An adult female and two young (eyes still closed) were removed from a nest box on May 28, 1955. An adult female was captured in another box in the same area on June 10. The boxes were rechecked on August 26th and an adult and two half-grown young were observed in a tree which had a nest box attached to the trunk. Four of six nesting boxes set up on Butte Creek were used in some manner by the ring-tails.

These records are of interest because they show appropriation of wood duck boxes by ring-tails for use as denning sites, and because the animals were found outside of what is considered typical habitat. The rocky, chaparral-covered foothill country of the Upper Sonoran Life Zone that surrounds the Central Valley is the usual ring-tail range. —*A. E. Naylor and G. W. Wilson, Game Management Branch, California Department of Fish and Game, March, 1956.*

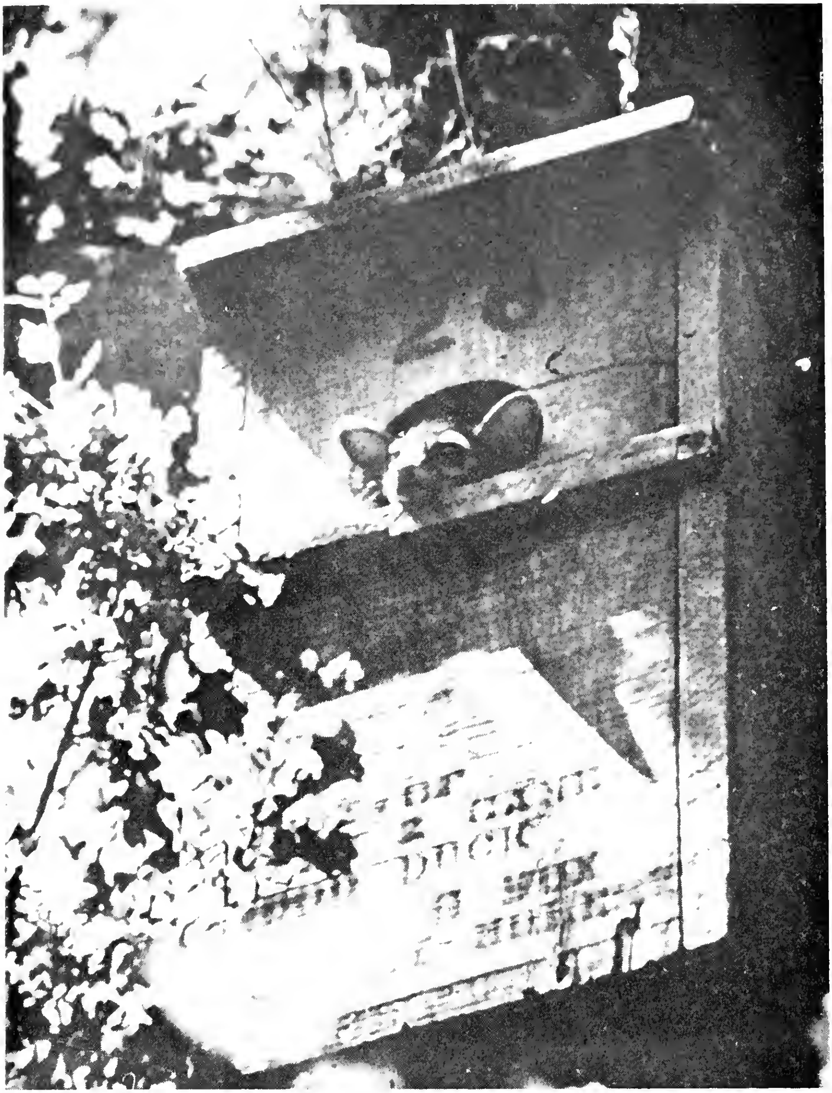

FIGURE 1. Ring-tailed cat in wood duck nest box.
Photograph by G. W. Wilson, May, 1955.

RETIREMENT

FRANCES N. CLARK

Dr. Frances N. Clark, director of the California State Fisheries Laboratory at Terminal Island for the last 17 years, retired on April 1 after 32 years of research and conservation work with the California Department of Fish and Game.

Through her work with the Department, principally on sardines, Dr. Clark has become known as one of the world's foremost authorities on marine fisheries. Her many publications, commencing with a doctoral thesis on the life history of the grunion, are well known to fisheries workers. Most of them deal with the life history, dynamics, and conservation of the California sardine.

Under her leadership the laboratory continued its biological and statistical programs and widened its activities to include several new research projects, among them the anchovy, yellowtail, surf perch, and kelp bass studies and an expanded high seas tuna program. All of these have been successful in providing new information on important fisheries.

Perhaps the finest testimonial to Dr. Clark's leadership abilities as a scientist and administrator is the roster of well-known fisheries workers who received their training under her guidance and who are now serving the public throughout the Department and in other agencies.

In recognition of her record, the Peruvian Guano Company, sponsored by the Peruvian Government, engaged her services in 1954 to survey the fisheries potential of that country and set up a research program.

In addition to her work in the sardine investigations and directing the laboratory, Dr. Clark has been a member of the technical advisory committee of the California Marine Research Committee and has acted in an advisory capacity for many public groups connected with the fisheries.

We in the Department will miss Dr. Clark—but look forward to her continued counsel as she enjoys her retirement.—*Richard S. Croker, Chief, Marine Fisheries Branch, California Department of Fish and Game.*

REVIEWS

Fish Saving: A History of Fish Processing From Ancient to Modern Times

By Charles L. Cutting; The Philosophical Library, Inc., New York, 1956; xv + 372 p., 16 figs. plus 45 plates. $12.

All the ingenious ways developed over the centuries for getting fish from ocean to consumer in something approaching edible form are learnedly described in this history. The origin and development of drying, salting, smoking, canning, icing, and freezing are outlined with fine understanding.

The book is surprisingly readable for one so crammed with technical details. The illustrations are good, and there are lots of them. This work will be valuable to fisheries technologists as a basic reference. Other fisheries workers will find it a stimulating account of fish processing, past and present, well worth reading. It should also intrigue the more adventurous general reader who is curious about the story behind such common delicatessen items as the "pickled herring" and the "finnan haddock."

A full history of herring curing in Europe follows introductory chapters on fish processing in early times. The "red herring" originated in the 14th Century. Its development into a common neologism resulted from its reputed ability to sidetrack even the keenest-nosed hound when drawn across a hot scent.

Several distinctive herring "cures" developed during the Middle Ages, all aimed at preserving a valuable, highly perishable product in the days before refrigeration.

The curing of fish with a low oil content, such as cod and haddock, is discussed next. Even as late as 1910, the major part of the North Atlantic catch of cod and related species was still being preserved by the traditional methods of salting and drying. The histories of these methods and their local applications are discussed minutely.

The canning of fish from its inception in the early 1800's is chronicled with many interesting sidelights, including the origin of the word "can".

Icing is also treated in detail. Interestingly enough, our European forefathers borrowed the idea of icing fish from the Chinese by way of India. They used it initially with great success in shipping salmon from Scotland to London in 1786. Ice was not taken to sea on trawlers until about 1850.

At one time the shipping of ice by sea from the Scandinavian countries to England for preserving fish was a thriving business, as was the gathering of ice on English ponds and its storage in great sheds for later use.

Other chapters deal with the transportation and distribution of fresh fish, the development of milder cures in recent times, freezing, and fisheries by-products.—*Alex Calhoun, California Department of Fish and Game.*

Matching the Hatch

By Ernest G. Schwiebert, Jr.; The Macmillan Co., New York, 1955; x + 221 p., illustrated by the author. $7.50.

This book is subtitled "A Practical Guide to Imitation of Insects Found on Eastern and Western Trout Waters" and is written for the advanced fly fishermen. The author believes that the fly fishermen's success is largely dependent upon using artificial flies that match the natural insect life present in the stream, and he does a very good job of describing insect life and the succession of aquatic insects that appear during the year, with emphasis on the mayflies.

This book concerns itself with streams in the East and in Colorado. The reviewer hesitates to recommend the author's charts on the times of mayfly hatches for use in California, where such a wide variety of stream and climatic conditions exists. Even so, the book is highly recommended to the serious trout fisherman.

The illustrations are excellent and the author states that identifications have been checked by competent entomologists. In contrast with many similar books, this is

one that is not written by an "old fisherman". The author is a 25-year-old architect, whose technical background is reflected in his style of writing and the quality of the illustrations. The author's interest in the subject is reflected in his almost professional familiarity with aquatic biology.—*Robert M. Paul, California Department of Fish and Game.*

The Marine and Fresh Water Fishes of Ceylon

By Ian S. R. Munro; Department of External Affairs, Canberra, Australia, 1955; xvi + 352 p., 19 text figs. and 56 plates. Price not listed.

Until this volume, descriptions of Ceylonese fishes have been scattered through a wide range of scientific publications not readily available to the average worker. The 856 species listed include all marine, brackish, and freshwater forms known from the waters of Ceylon. Included too are several introductions to freshwater and some rare deep-sea species from the Gulf of Manaar and other surrounding waters.

A brief diagnosis is provided for each species. These descriptions have been, for the most part, compiled from reliable standard reference works on fishes. Although generally good, the descriptions are not always adequate for distinguishing closely related species—too, many of the Ceylonese fishes have been insufficiently studied to permit adequate diagnoses. For identification there is a liberal sprinkling of keys throughout the 290 pages of descriptions. These keys are somewhat oversimplified but with them, and the descriptions, and figures, one should be able to name a species with reasonable assurance. Especially useful are the 56 black and white plates. Each illustrates 12 to 20 specimens and because these have been reduced to size and related forms presented on the same plate, they are particularly suited for making comparisons. The authority for each figure is quoted in the text immediately preceding the plate reference given with each specific description.

References to scientific literature are restricted to a citation of the original description and to the source of the figure employed (if different). Also, at the end of the text the author has included a five-page section listing alphabeticaly by author all the literature on Ceylonese fishes.

Common names, many of which were coined by the author for this volume, have been given for all species. In addition, Sinhalese and Tamil names, when available, have been included at the end of specific descriptions.

There is a glossary of technical terms and an excellent index.—*John E. Fitch, California Department of Fish and Game.*

North American Birds of Prey

By Alexander Sprunt, Jr.; Harper & Brothers, New York, 1955; 227 p., 46 plates in full color by Allen Brooks and others, plus 4 identificatiton silhouettes by Roger Tory Peterson. $5.

This book, published under the sponsorship of the National Audubon Society, is based upon, and supplementary to, "The Hawks of North America", by John Richard May. It includes the vultures, kites, accipiters, buteos, eagles, harriers, ospreys, caracaras, falcons, and owls. Frequent references are made to many other great works, including the two volumes on birds of prey in the life history series by Arthur C. Bent.

The author attempts to bring out the ecological niche of the birds of prey in the avian world and to correct some misunderstandings held by the public. Each species is described, with sections on identification, nesting habits, and range followed by a catch-all category entitled "history", which includes additions to the prior categories, characteristics, food habits, life history, and general status. The book stresses the value of these birds in controlling rodents and removing carrion. It points out that the harm done through predation is usually greatly exaggerated and that even the so-called "worst" birds of prey are helpful in keeping a healthy balance of nature.

The resting data and parts of the "history" are exceptionally fine and are very informative. The plates of the various birds, painted by well-known wildlife artists, are excellent. However, they are grouped together without page references, so that location of the bird's picture becomes a hit and miss proposition. Some of the field identifying marks are omitted and this, together with the difficulty in locating the bird's picture, makes identification a problem.

The book will appeal mainly to bird students, but will provide interesting reading for many who want to increase their knowledge of the birds of prey.—*Jack L. Hiehle, California Department of Fish and Game.*

Recent Studies in Avian Biology

Edited by Albert Wolfson; University of Illinois Press, Urbana, Illinois. 1955; ix + 479 p., 58 tables and figs. $7.50.

This comprehensive work is the product of thirteen distinguished co-authors, who wrote individual chapters more or less independently. Each chapter reviews a particular phase of avian biology to which substantial contributions have been made in recent years.

The purpose of the book may best be described by quoting from the preface: "There were two objectives in mind when the plan for the book was proposed. The first was to stimulate further research in ornithology. It was hoped to accomplish this by review and evaluation of recent data and concepts, by demonstration of our ignorance of important facts, and by the definition of basic problems. The second objective was to provide biologists in other fields with a convenient and authoritative source of the contributions of ornithological research to broader biological fields, such as systematics, evolution, anatomy, behavior, etc."

An outstanding feature of this book is an extensive bibliography following each chapter. Actually, over 1,500 references are cited. This alone is invaluable to anyone working in the wildlife field. By its nature the book is somewhat technical and in places is a bit difficult for an amateur to read. But, anyone who has an interest in any of the subjects covered can get a great deal out of the book.

Chapters 1 and 2 deal with systematics and evolution, Chapter 3 with paleontology. Avian anatomy and related problems are covered in Chapter 4, while in Chapter 5, the study of behavior in birds is covered. Chapters 6, 7, and 8 are concerned with separate problems of bird migration: orientation, annual stimulus and nocturnal migration.

The breeding biology of birds is treated in Chapter 9. Here the author has extracted a considerable amount of data and presents an extensive critique, but has omitted quite a bit of material because it did not meet his standards for statistical analysis. It might be said here that throughout the book the importance of having an adequate sample and of analyzing the data statistically is continually emphasized. (Unfortunately, an author is often forced to compromise between a comprehensive technical paper and one which will be readable and/or short enough to be published. In doing so, some details may have to be sacrificed.) It would be well worthwhile for anyone compiling life history data to read this chapter, to become aware of some of the weaknesses in our current data.

A scholarly review of recent advances in our knowledge concerning the role of hormones in the sex differentiation of birds is presented in Chapter 10, while Chapter 11 is devoted to American population research on gallinaceous birds. This chapter should be read by everyone concerned with game management work. Of special interest is the section on "Population Factors and Controls". Some of the methods of age determination for pheasants (page 335) do not seem to hold true for conditions in California. Also, the author's generalization on the possible effect of a strongly unbalanced sex ratio in a very sparse pheasant population (page 349) seems somewhat questionable. If a population reaches such a low density, it should hardly be considered a harvestable one. A good summary is given of the various census methods. Also, survival and mortality rates are discussed for the major species. The author remarks on "The Scarcity of Banding Data on Gallinaceous Birds in North America" (page 346) and offers as a possible solution the encouragement of amateur ornithologists to trap and band these birds. Another suggestion is that the U. S. Fish and Wildlife Service handle the record keeping for these species. I doubt that either the state game departments or the Fish and Wildlife Service will favor the latter. Other items covered in this chapter are sex and age ratios, and population fluctuations. The cycle problem is discussed at length and with much insight.

The title of Chapter 12 is "Birdbanding in the Study of Population Dynamics". To those who have wondered about the uses that can be made of banding data other than the determination of migration patterns, this chapter should be enlightening. This chapter is somewhat technical and may be confusing to some, but the terminology and basic premises are covered early in the chapter. General mortality and survival rates are discussed and examples given for several species. Special problems such as band loss are dealt with and then a review is given of data on population dynamics based on band recoveries for the various bird families.

As we analyze more of the accumulated band return data, we should be able to fill in many of the gaps indicated by the author. It is difficult to understand the author's reluctance to accept mortality data based on hunter-killed recoveries and, also, his concern over the differential vulnerabilty to shooting of immature and adult birds in calculating mortality.

A critical review and evaluation of our present knowledge of the diseases of birds is given in the final chapter of the book (Chapter 13). It emphasizes the meagerness of our data and the need for further work.

The book is a welcome addition to any wildlifer's library.—*A. W. Miller, California Department of Fish and Game.*

A Bibliography of References to Diseases of Wild Mammals and Birds

Compiled by Patricia O'Connor Halloran; American Journal of Veterinary Research, vol. 16, no. 61, October, 1955; part 2, xii + 465 p. $10.

This comprehensive compilation of over 8,000 references from more than 900 different publications covers the period from 1830 to 1950. The material is arranged according to the orders of mammals and birds. References for each order are then divided into infectious diseases, organ systems, physiological processes, and zoological miscellany. Variations in this general scheme occur and are dependent on the size and importance of the order. For example, some orders are subdivided by families or even by important individual animals.

The extensive coverage given the wide variety of host species is a reflection of Dr. Halloran's association with the Staten Island Zoo. Much of this material is of greatest value to zoo veterinarians. However, there are no purposeful omissions of reference material of primary interest to those working in the wildlife disease field, wildlife managers, and conservationists. Deliberate omissions were made in reference to rabbits, hamsters, and rats, inasmuch as Carlton M. Herman covered the rabbit, Hulda Magalhaes is working on the hamster, and the rat references are too great to include in this work.

The author makes no claim for completeness, and rightly so, since several important references are missing. In addition, there are a few errors in pages, volumes, and titles. However, when one considers the huge task that faced her, the errors and omissions may be easily overlooked.

This monumental undertaking will continue to serve as a valuable work for several reasons. It will provide impetus for research, and avoid costly duplication of past efforts. It will stimulate publication of information on wildlife diseases that might remain buried in official files. Authors will consult it as the primary source of reference material when preparing reviews of subjects within the scope of this bibliography.—*Merton N. Rosen, California Department of Fish and Game.*

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